INSTRUCTION MANUAL

BK PRECISION®

MODEL 3020

SWEEP/FUNCTION GENERATOR

B/C 02135

BK PRECISION®

TEST INSTRUMENT SAFETY

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Higher voltages pose an even greater threat because such voltages can more easily produce a lethal current. However, voltage as low as 35 volts DC or AC RMS should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly. Remove housings and covers only when necessary. Turn off equipment while making test connections in high voltage circuits.

2. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; and make certain such surfaces are not damp or wet. Where insulated floor surface is not available, wear heavy gloves.

3. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.

4. Always use an isolation transformer to power transformerless "hot chassis" equipment, where one side of the AC power line is connected directly to the chassis. This includes most recent television sets and audio equipment. Without an isolation transformer, the chassis of such equipment may be floating at line voltage (120 VAC, 60 Hz in USA), depending upon which way the 2-wire AC power plug is inserted. Not only does this present a dangerous shock hazard if the chassis is touched, but damage to test instruments or the equipment under test may result from connecting the ground lead of some test instruments to a "hot" chassis. The ground lead of most oscilloscopes and most other test instruments with 3-wire power plugs is at earth ground.

5. On test instruments or any equipment with a 3-wire AC power plug, use only a 3-wire outlet. This is a safety feature to keep the housing or other exposed elements at earth ground.

6. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.

7. Also remember that AC line voltage is present on some power input circuit points such as on-off switches, fuses, power transformers, etc., even when the equipment is turned off.

8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

INSTRUCTION MANUAL

FOR

MODEL 3020

SWEEP/FUNCTION

GENERATOR

BK PRECISION
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TABLE OF CONTENTS

	Page
INTRODUCTION	3
SPECIFICATIONS	5
OPERATOR'S CONTROLS	8
OPERATING INSTRUCTIONS	
Use as Function Generator	12
Use as Pulse Generator	15
Use as Sweep Generator	20
Use as Tone Burst Generator	23
TTL Output	24
Use as AM and DSB Signal Generator	25
Use as FM Signal Generator	27
External Control of VCG	28
External Control of Tone Burst Generator	30
Combinations of Modes	31
APPLICATIONS	
Introduction	33
Troubleshooting by Signal Substitution	33
Troubleshooting by Signal Tracing	34
Using the 3020 as a Bias and Signal Source	34
Amplifier Overload Characteristics	34
Amplifier Performance Evaluation Using Square Waves	35
Frequency Response Measurements	37, 64
Testing Speakers and Impedance Networks	40
AM Receiver Alignment	42
FM Communications Receiver Alignment	43
Testing Digital Logic Circuits	45
Testing Tone Burst Decoders	46
Testing Modulation Limiters and Compression Amplifiers	47
Preset Frequency Selection	49
Digital Frequency Selection	49
Additional Applications	50
THEORY OF OPERATION	
General Circuit Description	51
Detailed Circuit Description	51
MAINTENANCE AND CALIBRATION	
Removal of Rear Case	58
Line Voltage Conversion, Export Models	58
Fuse Replacement	59
Calibration Adjustments	60
WARRANTY SERVICE INSTRUCTIONS	68
LIMITED ONE-YEAR WARRANTY	68

INTRODUCTION

The Model 3020 Sweep/Function Generator is the most versatile signal source ever offered by **B & K-PRECISION.** It combines the operation of four instruments into one – function generator, pulse generator, sweep generator, and tone burst generator. With this versatility, it has a vast number of applications in both analog and digital electronics in the engineering, manufacturing, servicing, educational, and hobbyist fields.

The heart of the function generator is a VCG (voltage-controlled generator) that produces precision sine, square, or triangle waves over the .02 Hz to 2 MHz range. This encompasses subaudible, audio, ultrasonic, and RF applications. A continuously variable DC offset allows the output to be injected directly into circuits at the correct bias level.

Variable symmetry of the output waveforms converts the instrument to a pulse generator capable of generating rectangular waves or pulses, ramp or sawtooth waves, and slewed sine waves of variable duty cycle. All waveforms can be inverted.

The sweep generator offers linear or log sweep with variable sweep rate and sweep width up to 1000:1 frequency change. This allows one continuous sweep to cover the entire 20 to 20,000 Hz audio band. The frequency response of any active or passive device up to 2 MHz can be determined.

The tone burst generator chops the output into alternate on and off periods. Both the repetition rate and on/off duty cycle are variable. Tone burst testing is essential for speaker acoustics measurement, modulation limiter attack time measurement, tone burst decoder alignment, and many other applications. The tone burst is in integral half cycles of the frequency being gated. This allows synchronization of the waveform for oscilloscope viewing and eliminates transients and frequency components not harmonically related to the frequency being gated.

In addition to all the above features, an external signal may be applied to achieve amplitude modulation. Percentage of modulation is fully adjustable; also, the carrier can be suppressed to obtain a double-sideband, suppressed carrier signal. Most functions can be generated simultaneously; thus it is possible to test effects of simultaneous AM and FM modulation, or to sweep during tone bursts.

Further versatility is possible with external tone burst gating and external control of the VCG for operation such as programmable frequency control, FSK, and sweeping or FM'ing to an external control signal.

A fixed level TTL output is available in addition to the adjustable amplitude 50-ohm output, which can be varied from 20 millivolts to 20 volts peak-to-peak open circuit (10 millivolts to 10 volts peak-to-peak into 50 ohms). A sample of the generator control voltage (GCV) is also available for external use, such as horizontal sweep of an oscilloscope during sweep alignment or frequency response measurements.

SPECIFICATIONS

FREQUENCY CHARACTERISTICS

General

Frequency Range	.02 Hz to 2 MHz in 7 ranges.
Tuning Range	Each range provides 1000:1 frequency control.
Outputs	Sine, triangle, square wave, TTL square wave, pulse, ramp, skewed sine wave, tone burst, DC.
Accuracy	±5% of full scale to 1.5 MHz, ±8% from 1.5 MHz to 2 MHz (includes dial scale accuracy and range-to-range accuracy).
Stability	.05% after 15 minutes.
External Frequency Control (Rear Panel Input)	VCG tunable by 0 to +10.0 VDC. Frequency increases with positive voltage. Frequency may be programmed with DC voltages, FM-modulated with AC, or swept with ramp. VCG tuning range greater than 1000:1; with dial setting of .002, 0 to 10 volt ramp produces frequency change of 1000:1.
Generator Control Voltage Output	GCV OUT jack on rear panel provides 0 to 2.0 volts output proportional to dial setting or sweep frequency.
Variable Symmetry	Variable over 1:1 to 40:1 range. Independent of frequency. Controls all output waveforms, including TTL. Adjusts square wave to rectangular wave or pulse, triangle wave to ramp or sawtooth, slews sine wave.
AM Modulation	1.5 V p-p external signal provides 100% modulation. Percentage of modulation continuously variable. Capable of suppressed carrier operation.
DC Offset	Continuously variable; maximum of ±10 V open circuit, ±5 V into 50 ohms. Maximum V_{AC} peak + V_{DC} offset without clipping is ±20 V open circuit, ±10 V into 50 ohms.
Polarity	Inverted or non-inverted.

Square Wave

	Variable amplitude.
Symmetry	99% to 100 kHz.
Rise/Fall Time	Less than 100 nSEC at maximum output.

Sine Wave	Variable amplitude.
Distortion	Less than 1%, 0.2 Hz to 100 kHz; less than 0.5% typical. Harmonics more than 25 dB below fundamental, 100 kHz to 2 MHz. Distortion specifications apply from dial settings of .2 to 2.0.
Amplitude Flatness	Better than ±0.3 dB to 2 MHz at maximum output amplitude.
Triangle Wave	Variable amplitude.
Linearity	99% to 100 kHz.
TTL Output	Rear panel jack. Drives up to 20 TTL loads.
Level	Fixed amplitude, logic 0 less than 0.4 V; logic 1 more than 2.4 V.
Rise/Fall Time	Less than 25 nSEC.

SWEEP CHARACTERISTICS

Internal	Linear or log.
Sweep Rate	0.5 Hz (2 SEC period) to 50 Hz (20 mSEC period), continuously variable.
Sweep Width	Variable from 10:1 to 1000:1.
Sweep Voltage Output	Proportional to frequency. Rear GCV OUT jack. 0 to 2 volt ramp proportional to 1000:1 sweep.
External Sweep	Rear panel VCG IN jack. Input impedance is 1 kilohm.

TONE BURST CHARACTERISTICS

Burst Gate	Internal or external.
Burst Width	*Internal:* adjustable from 5 to 90% of period of internal gating frequency. *External:* accepts any TTL gating pulse, logic 0 less than 0.8 V, logic 1 more than 2.0 V.
Repetition Rate	*Internal:* 0.5 Hz to 50 Hz (2 SEC to 20 mSEC period) set by SWEEP RATE control. *External:* per external gating pulse.

Burst Frequency	As determined by range switch and frequency dial. Tone burst is in integral half cycles of frequency being gated. Burst can also be swept or AM modulated.

OUTPUT

Amplitude	20 V p-p open circuit, 10 V p-p into 50 ohms.
Attenuation	0 to -60 dB. Pushbutton-selectable, fixed attenuation steps of -10 dB, -10 dB and -20 dB. Continuously variable 0 to -20 dB. All selected attenuation cumulative.
Impedance	50 ohms, ±5%.

MISCELLANEOUS SPECIFICATIONS

Rear Panel Jacks	VCG IN, GCV OUT (proportional to frequency), AM IN, TTL OUT, .external tone burst control input (GATE IN).
Max. Voltage Limit	VCG IN: 13V AM IN: 5 V p-p GATE IN: 0 - 5 V TTL
Impedance	VCG IN: 1 kilohm AM IN: 10 kilohm GATE IN: TTL
Operating Environment	0 to 50°C (accuracy specified at 25° ± 5°C).
Power Requirements	105-130 VAC, 60 Hz, 22 W. Three-wire cord. (105-130/210-260 VAC, 50/60 Hz version available).
Size (HWD)	8.1 x 29 x 20 cm (3.2 x 11.3 x 7.7") including handle at rest position.
Weight	1.35 kg (3.1 lbs.).
CSA Listed	Yes.

Unless otherwise stated, specifications apply from dial setting of 0.2 to 2.0. Dial settings below 0.2 are intended for sweep operation only.

OPERATOR'S CONTROLS
(See Fig. 1 and 2)

1. **FREQuency dial.**

2. **RANGE switch.** On-off switch and frequency range selector.

3. **FUNCTION switches.** Select sine wave, square wave or triangular wave output.

4. **SWEEP WIDTH control.** On-off switch for internal sweep generator; adjusts magnitude of sweep. With switch OFF, no sweep is generated unless external sweep voltage is applied to VCG IN jack.

5. **SWEEP RATE control.** Adjusts sweep rate of internal sweep generator and repetition rate of burst gate.

6. **LIN/LOG switch.** Selects internal linear or logarithmic sweep.

7. **SYMMETRY control.** Adjusts symmetry of output from 1:1 (CAL position) to 40:1.

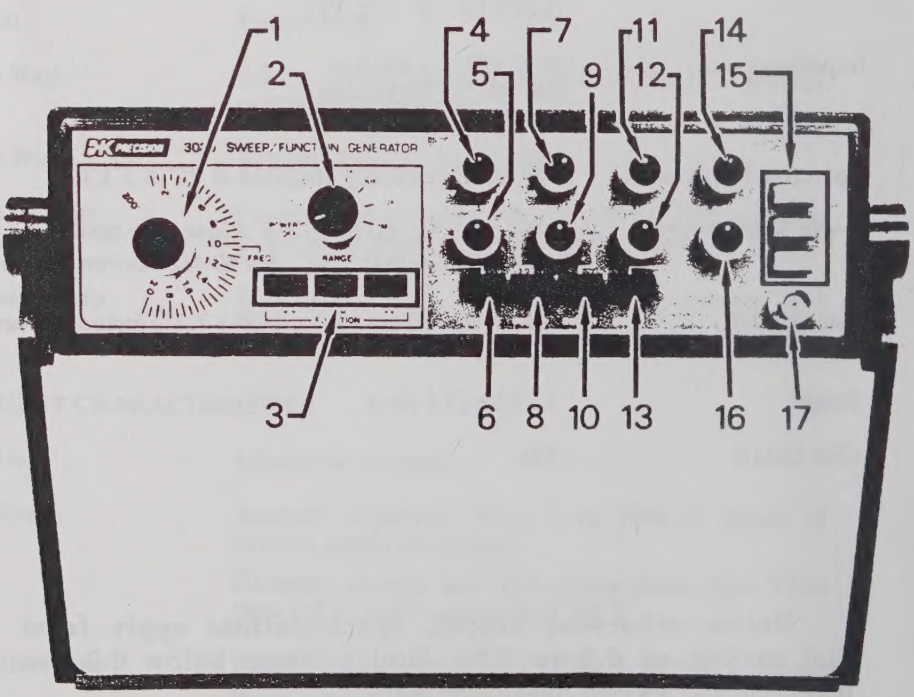


Fig. 1. Front panel operator's controls.

8. **NOR/INV switch.** Selects normal or inverted polarity of output waveform.

9. **BURST GATE control.** Adjusts duty cycle of tone burst gate from 5% to 90%.

10. **EXT/INT switch.** Selects external or internal burst gate. Continuous output is obtained with switch in EXT position and no external burst gate applied.

11. **CARRIER LEVEL control.** Adjusts degree of carrier suppression in AM mode.

12. **MOD LEVEL control.** Adjusts percentage of AM modulation.

13. **CW/AM switch.** Selects continuous wave or amplitude modulation operation.

14. **AMPLITUDE control.** Adjusts output level from 0 to -20 dB, in addition to any attenuation selected by the ATTENUATOR pushbuttons.

15. **ATTENUATOR.** Selects output level in 10 dB steps from 0 to -40 dB.

16. **DC OFFSET control.** Adds positive or negative DC component to output signal.

17. **50Ω output jack.**

18. **Carrying handle/tilt stand.**

19. **GCV OUT jack.** Generator control voltage output. Voltage is proportional to frequency.

20. **VCG IN jack.** Voltage controlled generator input. Permits external sweep or frequency control. SWEEP WIDTH control should be OFF when applying external voltage at this jack.

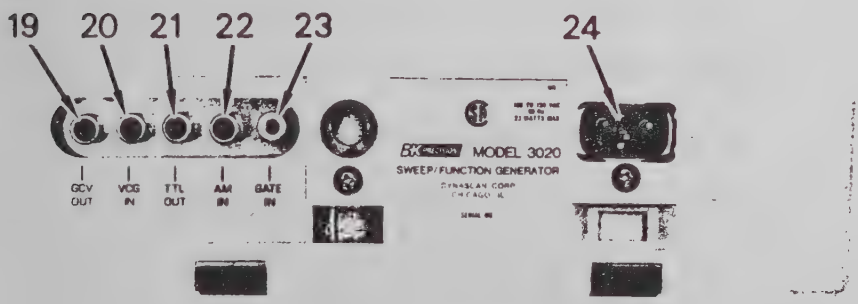


Fig. 2. Rear panel jacks.

21. **TTL OUT jack.** TTL counterpart of 50Ω output, signal is fixed level TTL square wave or pulses.

22. **AM IN jack.** Amplitude modulation input jack.

23. **GATE IN jack.** Input jack for external burst gate.

24. **Line cord receptacle.**

25. **Optional Accessories** (not shown). The following optional accessories are suitable for use with the Model 3020 Sweep/Function Generator.

    A. **B & K-PRECISION Model LC-50 Carrying Case.** Provides convenience and protection when you transport the instrument. Rugged construction. Space for cables and manual.

    B. **Instrument Connecting Cables and Adapters.** A BNC receptacle is used as the 50Ω output on the front panel of the 3020. Phono jacks are used as the TTL OUT, VCG IN, GCV OUT, AM IN, and GATE IN on the rear panel. Two phono plugs are supplied with the generator for adapting coaxial connecting cables to mate with these jacks. Also the following cables and adapters are available, if desired, for versatility in connecting to a variety of other equipment:

    B & K-PRECISION Cables:

Model	Description
CC-41	36″ RG/58U coax, BNC on each end.
CC-42	36″ RG/58U coax, BNC to UHF (PL-259).
CC-43	36″ RG/58U coax, BNC to dual banana plugs.
CC-44	36″ RG/58U coax, BNC to microphone connector.
CC-45	36″ RG/58U coax, BNC to type N.
CC-49	36″ audio coax, phono plug to dual banana plugs.
CC-51	20″ audio coax, phono plug to alligator clips.

Adapters (available from most electronics parts distributors):

BNC receptacle to phono plug: Adapts BNC-terminated cable to plug into rear panel phono jacks (Pomona Electronics Model 2957 or AVA Electronics Model 1051-24SP).

Phono jack to BNC plug: Adapts phono plug terminated cable to connect to BNC receptacle (Pomona Electronics Model 4054 or AVA Electronics Model 1030-34SP).

OPERATING INSTRUCTIONS

The Model 3020 Sweep/Function Generator is capable of generating an immense variety of output waveforms. The most benefit and satisfaction can be gained from the instrument by fully understanding its capabilities and versatility and becoming proficient in its operation. One of the best ways to initially gain this familiarization is to connect the generator to an oscilloscope, observe the waveforms, and notice the effects of the various controls on the waveforms. Use this manual as required for reference until becoming accustomed to the operating procedures.

USE AS FUNCTION GENERATOR

Procedure

1. Connect AC power cord into receptacle on rear panel and plug into outlet.

2. To turn on equipment, set RANGE switch to any position except POWER OFF.

3. To make sure that the output is symmetrical and unaffected by the sweep generator, burst gate or other controls, set the following controls as specified:

CONTROL	POSITION	CONTROL	POSITION
SWEEP WIDTH	OFF (fully ccw)	CW/AM	CW (button out)
SYMMETRY	CAL (fully ccw)	DC OFFSET	centered
EXT/INT	EXT (button out; no connection to GATE IN jack on rear panel)		

4. To select the desired frequency, set the RANGE switch and FREQ dial as follows: The output frequency equals the FREQ dial setting times the RANGE switch setting. For example, a FREQ dial setting of .6 and a RANGE switch setting of 10K produces a 6 kHz output (.6 x 10K = 6K). A FREQ dial setting of 2.0 and a RANGE switch setting of 1M produces 2 MHz output (2.0 x 1M = 2M). A FREQ dial setting of .2 and a RANGE switch setting of 1 produces 0.2 Hz output (.2 x 1 = .2).

5. Select sine, square, or triangle wave output by pressing the corresponding FUNCTION button. Fig. 3 illustrates the output waveforms and their phase relationships.

6. Connect a cable from the 50Ω jack to the point where it is desired to inject the signal.

7. Adjust the 50Ω output to the desired amplitude with the AMPLITUDE control. Also push as many of the ATTENUATOR buttons as necessary to reduce the amplitude to the required level, or release buttons to increase the amplitude.

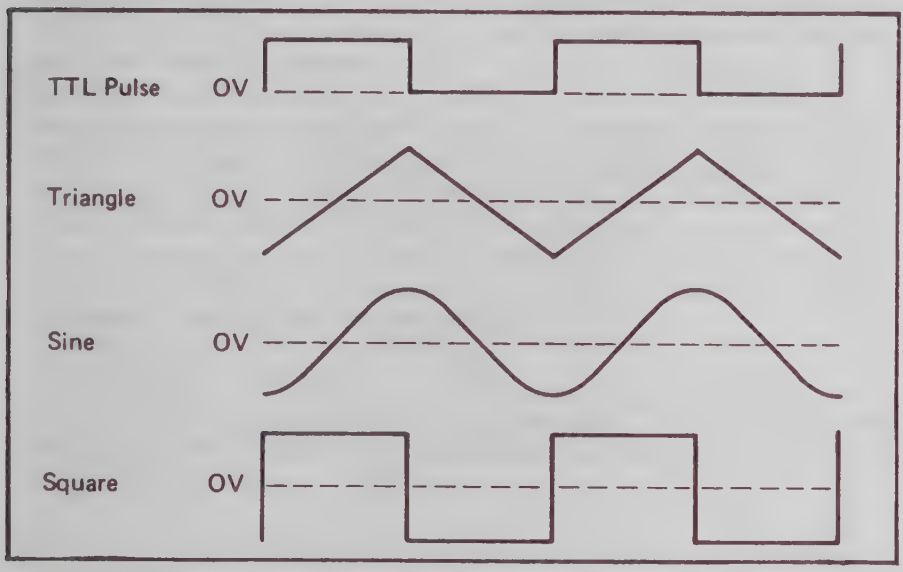


Fig. 3. Output waveforms and phase relationships.

8. A positive or negative DC component can be added to the signal at the 50Ω jack by use of the DC OFFSET control, as required by the circuit into which the signal is being injected.

9. A fixed amplitude TTL square wave is available at the TTL OUT jack on the rear panel. This signal is unaffected by the AMPLITUDE, ATTENUATOR, DC OFFSET, or NOR/INV controls. Since the TTL output is for use in digital circuits, only a square wave type signal is present, even though FUNCTION switches select sine or triangle wave.

10. The polarity of the output waveform may be reversed with the NOR/INV switch, although with symmetrical waveforms this is seldom required.

Considerations

Knowledge of the following factors is essential for proper operation of the instrument:

1. The DC OFFSET control can provide up to ±10 volts open-circuited, or ±5 volts into 50 ohms. Remember that the combined signal swing plus DC offset is also limited to ±10 volts open-circuited, or ± 5 volts into 50 ohms. Clipping

occurs slightly above these levels. Fig. 4 illustrates the various operating conditions encountered when using DC offset. If the desired output signal is large or if a large DC offset is used, an oscilloscope should be used to make sure that the desired combination is obtained without clipping. The probability of clipping is reduced by keeping the AMPLITUDE control in the lower half of its adjustment range when possible.

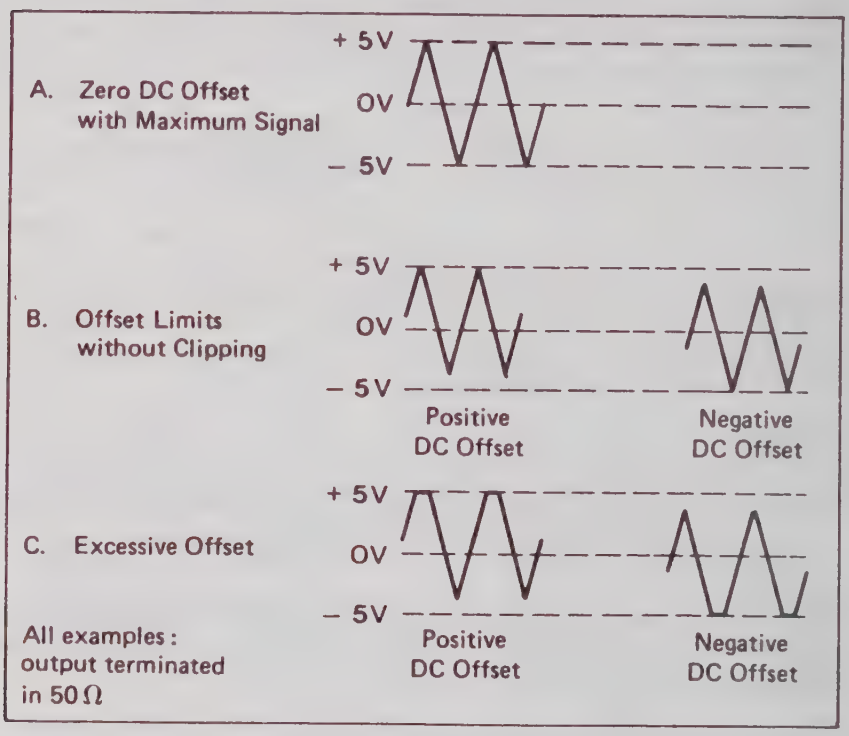


Fig. 4. Use of DC OFFSET control.

2. To set the DC OFFSET to zero or a specific DC voltage, depress the FUNCTION switches slightly so that all switches are released (all buttons out). This removes signal from the output and leaves the DC only. Measure the DC output on an oscilloscope or DC voltmeter and adjust the DC OFFSET control for the desired value. Although the AMPLITUDE control does not affect the DC offset, the DC output passes through the selected ATTENUATOR steps. Be sure to use the same amount of attenuation when setting the DC OFFSET that will be used when signal is added.

3. It is easier to accurately set the FREQ dial if settings between .1 and 2.0 are used. Since the dial rotation overlaps ranges, it is not usually necessary to use readings below .1; just change to a lower range and use a higher dial setting. The .002 setting is intended primarily for sweep generator operation.

4. The main output jack is labeled 50Ω. This means that the source impedance is 50 ohms, but the output may be fed into any circuit impedance. However, the output level varies in proportion to the terminating impedance. If it is desired to maintain a constant output level while injecting signal into various circuits with various impedance, a constant terminating impedance is necessary. When the generator output is connected to a coaxial connector on the equipment under test, it usually presents a 50-ohm terminating impedance. Most other circuit points are usually moderate to high impedance. A reasonably constant terminating impedance may be maintained while injecting signal into moderate and high impedance circuits (500 ohms and up) by adding a coaxial tee in the output cable and connecting a 50-ohm termination to one leg. Remove the 50-ohm termination when injecting into a 50-ohm circuit. Also keep DC considerations in mind. If DC voltage is present at the signal injection point, the DC OFFSET should be set to match the circuit voltage, or a blocking capacitor may be required to avoid DC loading with 50 ohms.

5. When using the higher output frequencies and when using the square wave output, terminate the cable in 50 ohms to minimize ringing. Keep the cables as short as possible.

6. To set output amplitude to a specific level, measure peak-to-peak amplitude on an oscilloscope.

7. To set the output frequency with greater precision (dial accuracy is within 5%), connect the output to a frequency counter.

USE AS PULSE GENERATOR

In a symmetrical square wave, sine wave, or triangle wave, the positive and negative transitions are of equal time duration, or 1:1 ratio. This is the condition when the SYMMETRY control is set to the CAL position. When the SYMMETRY control is rotated, the positive transition can be stretched in relation to the negative transition, up to at least 40:1 ratio. Square waves can be stretched into rectangular waves or pulses, triangle waves can be stretched into ramp or sawtooth waves, and sine waves can be stretched into a distorted waveshape called a slewed sine wave. An inverter allows either polarity output to be selected Fig. 5 illustrates the types of waveforms possible and includes a summary of control settings used to obtain the desired waveform.

Procedure

1. Set up generator as described for function generator operation. Display the output of the generator on an oscilloscope.

2. Select the desired type of waveform with the FUNCTION switches. Press the square wave button for pulses, triangle button for ramp waves, or sine button for slewed sine waves.

3. Select the desired polarity with the NOR/INV switch. See Fig. 5 for reference.

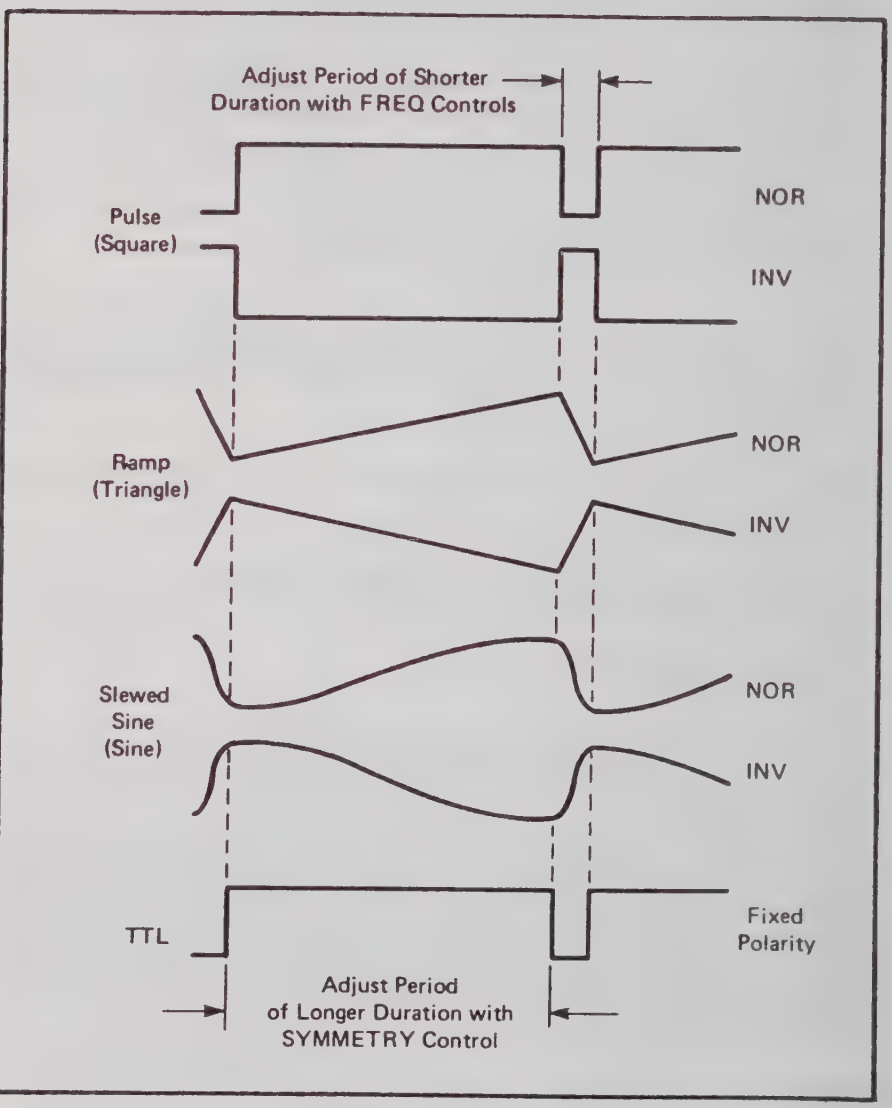


Fig. 5. Pulse, ramp, and slewed sine wave generation.

4. If both a specific pulse width and repetition rate are required (both specific rise time and fall time for ramp wave), the waveform may be obtained as follows:

   a. Adjust the shorter duration portion of the waveform (pulse width for pulses, fall time for ramp waves) with the frequency controls – FREQ dial and RANGE switch.

   b. Adjust the longer duration portion of the waveform (rest time for pulses, rise time for ramp waves) with the SYMMETRY control.

   c. Fig. 6 and 7 give a typical example for obtaining a specific pulse waveform.

5. If a specific pulse width (specific fall time for ramp wave) is not critical, but a specific repetition rate is required, the desired waveform may be obtained as follows:

   a. Observe the oscilloscope and adjust the SYMMETRY control to obtain the approximate desired pulse width vs. rest time ratio (rise time vs. fall time ratio for ramp waves).

   b. Adjust the repetition rate with the frequency controls – FREQ dial and RANGE switch. The frequency controls affect both the pulse width and repetition rate.

Considerations

1. When generating ramp waves or slewed sine waves, it may be easier to measure the time periods on the oscilloscope using the square wave mode, then switch to the desired operating mode.

2. For ease and accuracy in measurement, use a higher sweep speed on the oscilloscope to expand the pulse width for measurement, then reduce sweep speed to measure the repetition rate.

3. Repetition rate may be expressed as a frequency or time period. Measure the repetition rate as a time period on the oscilloscope and convert to frequency if required. The repetition rate includes the full cycle, both the pulse width and rest time for pulses, both the rise time and fall time for ramp waves.

4. Repetition rate can be measured accurately and easily as a frequency or time period with a frequency counter.

5. Pulse width also can be measured on a frequency counter, but only with the SYMMETRY control set to CAL before the pulse waveform is "stretched". Pulse width equals one-half the timp period of the square wave (see Fig. 7C). If

the counter is not equipped for period measurement, calculate the frequency which is equivalent to the desired pulse width and measure the frequency of the waveform.

$$\text{desired frequency} = \frac{1}{\text{desired pulse width} \times 2}$$

6. The generator's frequency controls establish the time period of the shorter duration portion of the waveform. Adjusting the SYMMETRY control does not interact with the frequency controls and will not affect this time period. However, the FREQ dial and RANGE switch affect both the shorter and longer duration portions of the waveform. The SYMMETRY control establishes the ratio between the shorter and longer portions of the cycle. After the SYMMETRY control has been adjusted, any small change in the setting of the FREQ dial will be multiplied by the symmetry ratio and have a large effect on the time period of the longer duration portion of the waveform. When adjusting for a specific pulse width, set the FREQ dial first, then the SYMMETRY control.

7. The setting of the frequency controls indicates the generator's output frequency only when symmetrical waves are being generated. It does not indicate the repetition rate when using the instrument as a pulse generator. The frequency controls indicate the frequency which corresponds to the shorter portion of the cycle. If the waveform is "stretched" so that the rest time is "several times" greater than the pulse width, the frequency control settings are "several times" greater than the repetition rate of the output. The multiplying factor is proportional to the setting of the SYMMETRY control.

8. To generate a pulse waveform in which pulse width is greater than rest time, use the techniques and procedures as described in this manual, except reverse the roles of pulse width and rest time. Adjust rest time first, as this manual prescribes for the shorter duration portion of the waveform, using the FREQ dial. Treat pulse width like this manual prescribes for the longer duration portion of the waveform. Adjust it to the desired period with the SYMMETRY control. Select the desired polarity with the NOR/INV switch.

Typical Example

Assume that it is desired to generate a pulse waveform with a 40-microsecond pulse width and repetition rate of 2.5 kHz. The following procedure, along with Figs. 6 and 7, describe how to connect equipment, set controls, and interpret measurements to obtain this pulse waveform. Pulse waveforms of other pulse widths and repetition rates may be obtained similarly. Steps of the procedure must be performed in the sequence specified.

1. Connect equipment as shown in Fig. 6 Set the SYMMETRY control to CAL.

2. Adjust FREQ dial (and RANGE switch if necessary) for desired pulse width.

   a. Increase oscilloscope sweep speed to expand waveform for convenient calibration time measurement.

   OR

   b. Measure time period of waveform using period measurement function of frequency counter. Adjust for *twice* the pulse width period.

   OR

   c. Calculate frequency which is equivalent to desired pulse width (freq. = $\frac{1}{\text{pulse width} \times 2}$) and measure frequency of waveform on counter. Adjust to obtain calculated frequency.

3. Adjust the SYMMETRY control to obtain the desired repetition rate.

   a. Reduce oscilloscope sweep speed. Display waveform and measure repetition rate period using calibrated time measurement. If repetition rate is stated as a time period such as 400 microseconds, adjust the SYMMETRY control so that a complete cycle of pulse width and rest time equals 400 μSEC. If the desired repetition rate is expressed as a frequency, such as 2.5 kHz, first calculate the equivalent time period (period = $\frac{1}{\text{freq.}}$), then proceed as described above.

   OR

   b. If desired repetition rate is stated as a frequency, measure the frequency on a frequency counter and adjust the SYMMETRY control to obtain the desired repetition rate.

   OR

   c. If the desired repetition rate is stated as a time period, use the period measurement function of the frequency counter and adjust the SYMMETRY control to obtain repetition rate period.

   OR

   d. If the desired repetition rate is stated as a time period, calculate the equivalent frequency (freq. = $\frac{1}{\text{period}}$), then perform step b.

4. Select the desired polarity with the NOR/INV switch. The shorter duration portion, which we have called the pulse width, will be the negative portion with NORmal polarity and positive with INVerted polarity. The pulse output can also be taken from the TTL OUT jack, but polarity is not reversible.

5. Adjust the pulse waveform to the desired amplitude with the AMPLITUDE control and ATTENUATION buttons. Measure the peak-to-peak voltage amplitude on the oscilloscope. (Fixed amplitude at proper TTL levels from TTL OUT jack.)

6. Use DC coupling on the oscilloscope and adjust the DC OFFSET control for

the desired DC reference level for the waveform (TTL output is independent of DC OFFSET control).

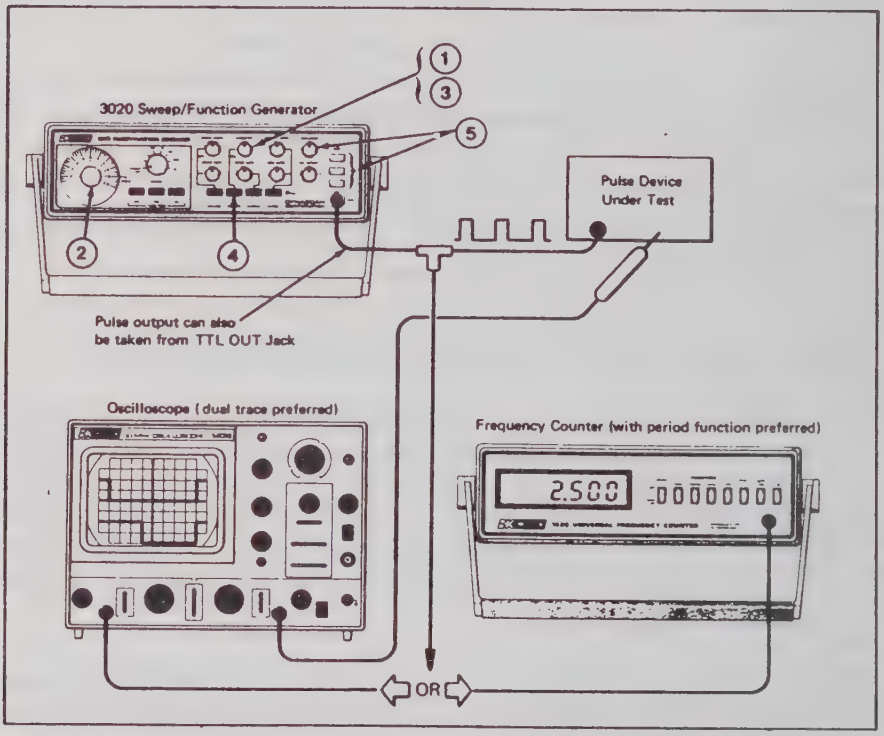


Fig. 6. Typical set-up for pulse generation.

USE AS SWEEP GENERATOR

Procedure

1. Set up equipment as for function generator operation.
2. Select linear or logarithmic sweep with the LIN/LOG switch.
3. Select the highest frequency to be swept with the RANGE switch and the lowest frequency to be swept with the FREQ dial.
4. Adjust the amount of sweep with the SWEEP WIDTH control.
5. Adjust the repetition rate of the sweep with the SWEEP RATE control.

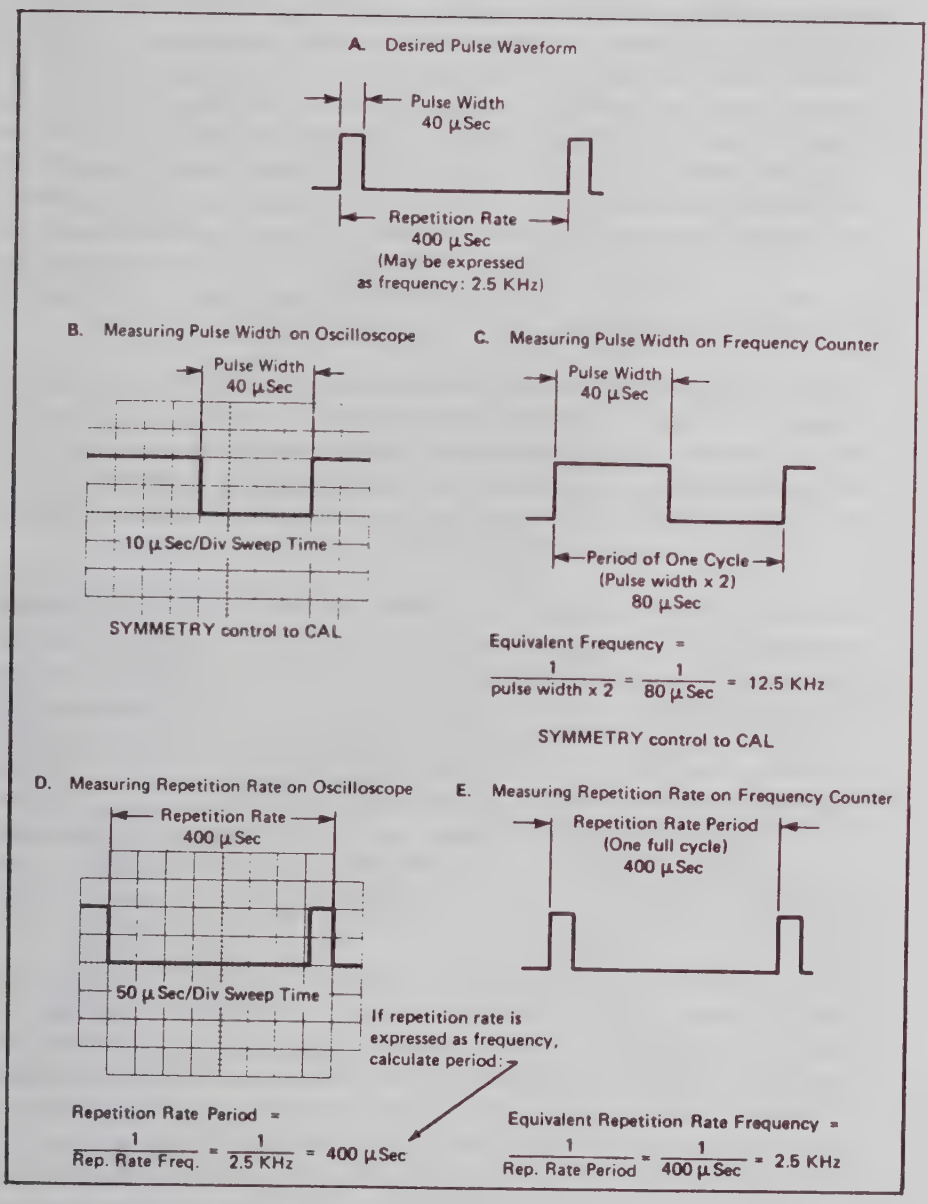

A. Desired Pulse Waveform
Pulse Width
40 μSec
Repetition Rate
400 μSec
(May be expressed
as frequency: 2.5 KHz)
B. Measuring Pulse Width on Oscilloscope
Pulse Width
40 μSec
10 μSec/Div Sweep Time
SYMMETRY control to CAL
C. Measuring Pulse Width on Frequency Counter
Pulse Width
40 μSec
Period of One Cycle
(Pulse width x 2)
80 μSec
Equivalent Frequency =
1 / pulse width x 2 = 1 / 80 μSec = 12.5 KHz
SYMMETRY control to CAL
D. Measuring Repetition Rate on Oscilloscope
Repetition Rate
400 μSec
50 μSec/Div Sweep Time
If repetition rate is
expressed as frequency,
calculate period:
Repetition Rate Period =
1 / Rep. Rate Freq. = 1 / 2.5 KHz = 400 μSec
E. Measuring Repetition Rate on Frequency Counter
Repetition Rate Period
(One full cycle)
400 μSec
Equivalent Repetition Rate Frequency =
1 / Rep. Rate Period = 1 / 400 μSec = 2.5 KHz

Fig. 7. Typical pulse measurement and set-up technique.

6. To sweep the entire 20 Hz to 20,000 Hz audio range, set the RANGE switch to 10K, FREQ dial to .002, and SWEEP WIDTH control fully clockwise.

Considerations

1. A .002 or low end FREQ dial setting is recommended for most sweep generation operation. The lowest frequency of the generator is determined by

the dial setting. The sweep generator will sweep upward from that point. However, it will sweep upward only to the range limit (highest frequency to which the dial can tune on the selected range). Therefore, a low dial setting is required to obtain a sweep covering a wide frequency range. The .002 setting must be used to obtain the maximum sweep width of 1000:1 (highest frequency sweep is 1000 times that of lowest frequency swept). If a high dial setting and high SWEEP WIDTH setting are used simultaneously, the generator will sweep to the range limit and cease operation for a portion of the sweep cycle, effectively clipping the sweep. Of course, if only a small frequency band is to be swept, a low dial setting is not important. In fact, it may be easier to set to the desired frequencies if the dial setting is .1 or higher.

2. The GCV OUT jack on the rear panel provides a voltage that is proportional to the output frequency, and is directly proportional to the dial setting when the sweep generator is off. A dial setting of .002 produces approximately 0 volts, a dial setting of .2 produces -0.2 volt, a dial setting of .5 produces -0.5 volt, etc., to a dial setting of 2.0, which produces -2.0 volts. The voltage is present in the form of a negative-going sweep voltage during sweep operation.

3. Determining how to properly set the SWEEP WIDTH control is fairly simple using the GCV OUT voltage. Connect the GCV OUT voltage to an oscilloscope using DC coupling. Before starting sweep operation set the RANGE switch to the same position that will be used in subsequent sweep operation, and the FREQ dial to the lowest frequency to be swept. Mark the trace position on the face of the oscilloscope with a grease pencil, then set the dial to the highest frequency to be swept and again mark the trace position. Use the oscilloscope gain and centering controls to position and separate the markers conveniently. Return the FREQ dial to the lower setting and begin sweep operation. Adjust the SWEEP WIDTH control so the oscilloscope deflection spans the space between the two markers.

4. Setting of the SWEEP RATE control is dependent upon the frequencies being swept. A lower repetition rate (ccw rotation of SWEEP RATE control) is required for sweeping of low frequencies, and a high repetition rate (cw rotation of SWEEP RATE control) may be used for sweeping higher frequencies. The sweep rate must be low enough to allow a few cycles of generator output at the low frequency end of the sweep before the generator sweeps into mid-range. The LOG sweep is sometimes preferred because it does not sweep through the low frequencies as rapidly. A higher sweep rate reduces flickering of the oscilloscope for viewing convenience.

5. This manual contains two procedures for using the sweep generator to perform frequency response measurements. A summary of each method follows:
   a. The linear display procedure, starting on page 37, is usually preferred when only a linear display is desired because frequency markers may be added very easily. This method uses the GCV OUT voltage as horizontal deflection to an oscilloscope (X-Y operation). Since GCV OUT voltage is

proportional to the output frequency in either manually dialed or automatic sweep operation, each frequency at which a marker is desired can be dialed before sweep operation begins and a mark added on the oscilloscope screen with a grease pencil. However, since horizontal deflection represents voltage instead of time, only a linear display is possible, even when the LIN/LOG switch selects LOG sweep. Also, since the GCV OUT voltage is negative going, the display sweeps from right to left on most oscilloscopes. That is, the lowest frequency appears on the right and the highest frequency appears on the left.

b. The linear/log display procedure, starting on page 64, permits the selection of a linear or logarithmic display with the LIN/LOG switch. This method uses the oscilloscope's internal sweep which is linear with respect to time. The display also sweeps in the conventional left-to-right direction. However, if frequency markers are desired, they must be calculated and added after the SWEEP RATE control and oscilloscope sweep speed have been set.

USE AS TONE BURST GENERATOR

In the tone burst generator mode of operation, an internally generated burst gate alternately gates the output on and off. Both the repetition rate and duty cycle are variable. Fig. 8 illustrates the type of waveform generated and summarizes the control settings used to obtain the desired waveform.

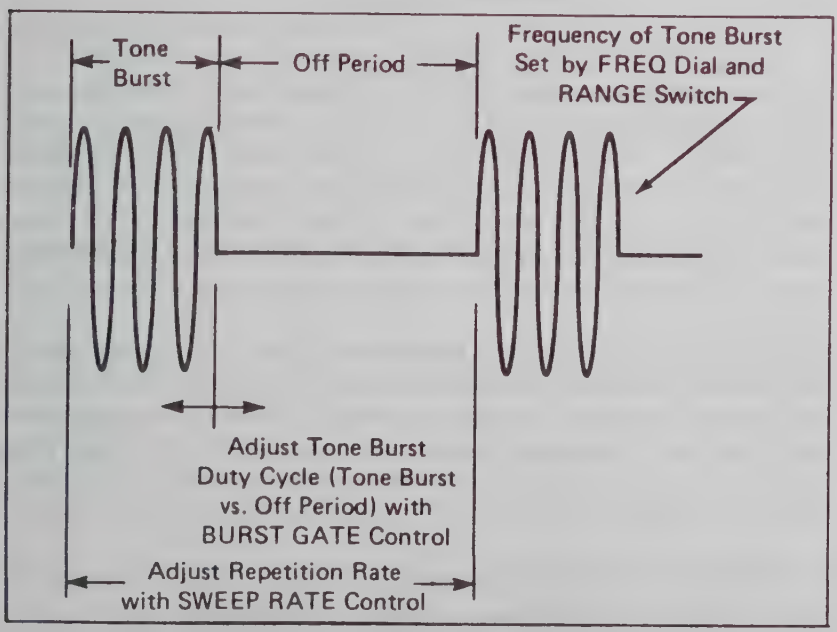

Tone Burst
Off Period
Frequency of Tone Burst Set by FREQ Dial and RANGE Switch
Adjust Tone Burst Duty Cycle (Tone Burst vs. Off Period) with BURST GATE Control
Adjust Repetition Rate with SWEEP RATE Control

Fig. 8. Tone burst generator output waveform.

Procedure

1. Set up equipment as described for function generator operation. Display the output of the generator on an oscilloscope.

2. Select the frequency of the tone burst with the RANGE switch and FREQ dial.

3. Set the EXT/INT switch to the INT position (button in).

4. Adjust the repetition rate with the SWEEP RATE control.

5. Adjust the tone burst duty cycle, or adjust the tone burst width to a specific time period, with the BURST GATE control.

Considerations

1. If the tone burst waveform cannot be obtained on the oscilloscope initially, try rotating the BURST GATE control counterclockwise. At full clockwise rotation, the tone burst duty cycle is 0% and no output waveform is produced.

2. Make sure the tone burst and *entire* off period is viewed when setting the repetition rate. The visible portion of the off period could be incorrectly interpreted as the entire off period. To avoid this error, use a low sweep speed on the oscilloscope, adjusted to view the tone burst, off period, *and the beginning of a second tone burst.*

3. The BURST GATE control does not interact with the SWEEP RATE control and will not affect the repetition rate. However, both controls affect the tone burst width. Since the BURST GATE control adjusts the duty cycle (percentage of repetition rate cycle in which tone burst is produced), any subsequent adjustment of the SWEEP RATE control affects the tone burst width, as well as the off period. When setting the tone burst width to a specific time period, adjust the SWEEP RATE control first, then the BURST GATE control.

4. The tone burst output signal is always in full cycles or half cycles. Note that as the BURST GATE control is adjusted slowly, that the tone burst is increased or decreased in half cycle increments. This allows syncronization of the waveform for oscilloscope viewing and eliminates transients and frequency components not harmonically related to the frequency being gated. This feature is applicable to internal or external tone burst operation.

TTL OUTPUT

The TTL output is specifically designed for compatibility with TTL digital logic circuits. Set-up time is considerably reduced because the fixed logic levels and polarity are ready for direct injection into TTL circuits. There is no need for

adjustment of amplitude, DC offset, or polarity controls. This also affords protection from accidental application of too high amplitude or incorrect DC offset which might damage semiconductors. Another advantage is the extremely fast rise time and fall time of the signal.

To use the TTL output, connect a cable from the TTL OUT jack on the rear panel of the generator to the point at which it is desired to inject the signal. The TTL output may be used in several modes of operation. Some examples follow.

1. Using the square wave generator or pulse generator modes, clock pulses can be generated for testing, troubleshooting, or circuit analysis. The instrument could even be used as a substitute master clock generator; up to 20 TTL circuits can be driven from the TTL OUT jack.

2. A gated pulse train can be generated in the tone burst mode of operation.

3. In the sweep generator mode, a repeating series of square waves or pulses of progressively shorter duration can be generated. This may be used to evaluate the response characteristics of the circuit under test.

USE AS AM AND DSB SIGNAL GENERATOR

Procedure

1. Set up equipment as for function generator operation. Use the frequency and amplitude controls to set the carrier to the desired frequency and amplitude.

2. Connect the modulating signal to the AM IN jack on the rear panel. A 1.5 volt peak-to-peak (0.53 volt rms) signal will produce 100% modulation.

3. Set the CW/AM switch to AM (button in).

4. Adjust percentage of modulation with the MOD LEVEL control. Fig. 9 shows how to measure precentage of modulation with an oscilloscope.

5. Set the CARRIER LEVEL control fully ccw for AM operation. Turning the CARRIER LEVEL control clockwise reduces the carrier level, but not the double sidebands. Full suppression of the carrier produces a double sideband (DSB) signal. Fig. 9 illustrates the suppressed carrier waveforms.

Considerations

1. Use an oscilloscope to monitor the percentage of modulation.

2. Do not greatly exceed 1.5 volts peak-to-peak as a modulating signal. Otherwise, the degree of rotation of the MOD LEVEL control needed to achieve 100%

modulation is greatly reduced. Precise adjustment then becomes difficult for any desired percentage of modulation.

3. The frequency separation of the sidebands from the carrier is equal to the frequency of the modulating signal. For example, with a 1000 Hz modulating signal, sidebands are generated 1000 Hz above and 1000 Hz below the carrier frequency.

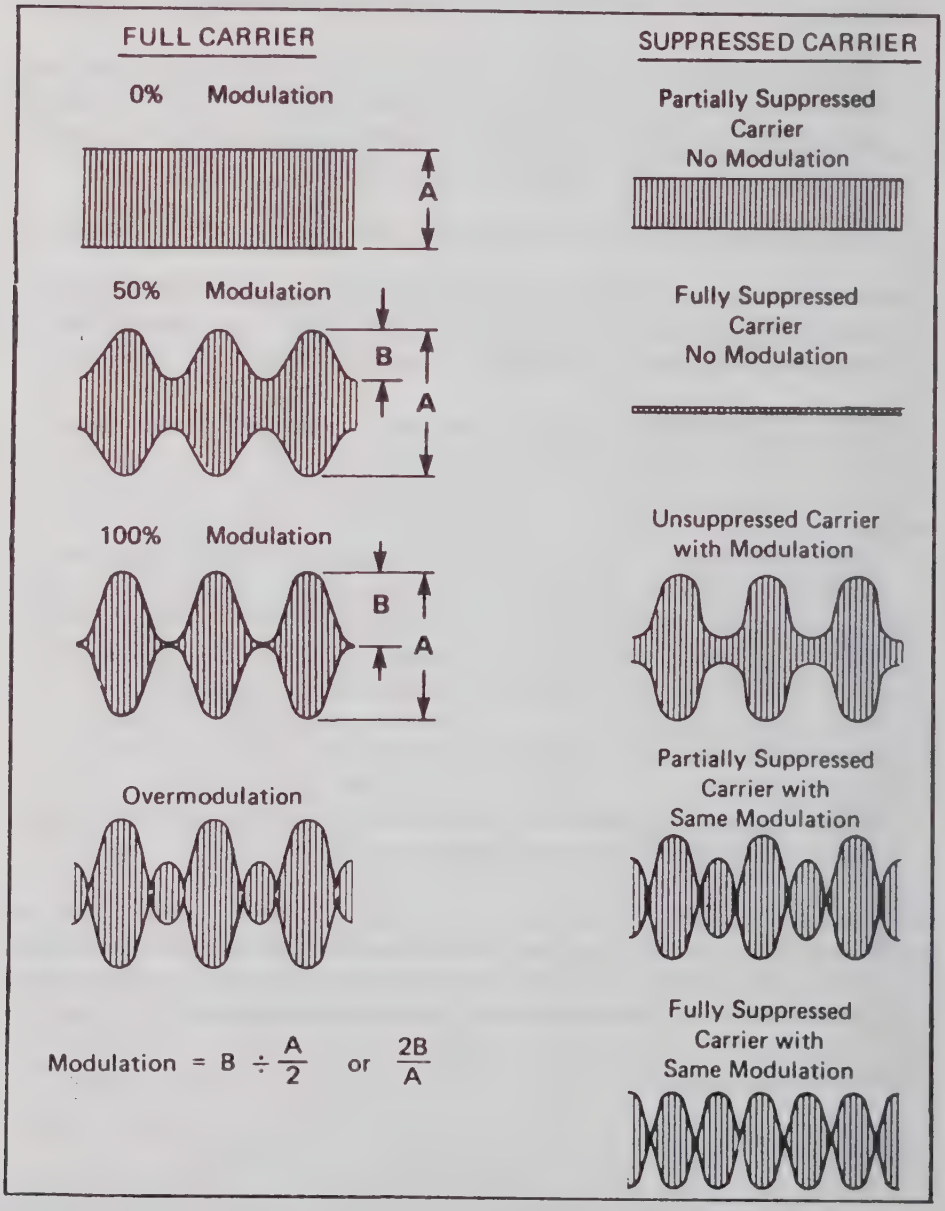


Fig. 9. AM modulation and suppressed carrier waveforms.

4. The modulating signal should contain no DC component. If necessary, use a coupling capacitor to block the DC component.

5. As the CARRIER LEVEL control is rotated from fully clockwise to fully counterclockwise, carrier level reduces from maximum to minimum, then increases with opposite polarity. Minimum carrier level is obtained at the null near the center of the CARRIER LEVEL adjustment range. This is easily seen with no modulation applied as shown in Fig. 9.

6. With a given modulating signal applied, the percentage of modulation increases as the carrier level is reduced. Significant reduction in the carrier level will produce over-modulation. Minimum carrier level is obtained when the overmodulation envelopes are of equal amplitude as shown in Fig. 9.

USE AS FM SIGNAL GENERATOR

Procedure

1. Set up equipment as described for function generator operation. Use the frequency and amplitude controls to set the carrier to the desired frequency and amplitude.

2. Connect an AC modulating signal with no DC component to the VCG IN jack on the rear panel of the generator.

3. Adjust the amplitude of the AC modulating signal for the desired frequency deviation.

Considerations

1. The approximate frequency deviation for a given VCG IN signal can be determined as follows: A 0.1 volt change at the VCG IN jack produces a frequency change of 1% of the highest frequency obtainable on a given range. For example, the highest frequency obtainable on the 100K range is 200 kHz. One percent of 200 kHz equals 2 kHz. Therefore, a 0.1 volt change at the VCG IN jack will deviate the output frequency 2 kHz on the 100K range. Table 1 summarizes the frequency deviation versus VCG IN voltage for all ranges.

2. As an example, assume that we wish to generate a 455 kHz signal with FM deviation of ±15 kHz (30 kHz swing). The 1M range will be used to obtain the 455 kHz carrier, with the FREQ dial set to 0.455. The highest frequency obtainable on the 1M range is 2 MHz. One percent of 2 MHz is 20 kHz. Our requirement of 30 kHz deviation is 1.5 times greater than the 20 kHz deviation produced by a 0.1 volt VCG IN swing, thus we will use 1.5 times as much peak-to-peak voltage swing, or 0.15 volt.

Stated another way:

$$\frac{\text{desired deviation}}{1\% \text{ deviation}} \times 0.1V = \text{required VCG IN signal}$$

Substituting this example:

$$\frac{30 \text{ kHz}}{20 \text{ kHz}} \times 0.1V = 1.5 \times 0.1V = 0.15V$$

3. Remember that the calculated VCG IN signal is the peak-to-peak amplitude.

RANGE	HIGHEST FREQ. OBTAINABLE (Hz)	FREQ. DEVIATION FOR EACH 0.1 VOLT VCG IN CHANGE (Hz)
1	2	.02
10	20	.2
100	200	2
1K	2 k	20
10K	20 k	200
100K	200 k	2 k
1M	2 M	20 k

Table 1. Frequency deviation versus VCG IN voltage.

EXTERNAL CONTROL OF VCG

Within a given range, the output frequency of the generator is normally controlled by the FREQ dial setting. However, it also may be controlled by applying voltage at the VCG IN jack on the rear panel. There are three basic modes of external VCG control possible, as follows:

a. Applying an AC voltage produces FM modulation (previously described in "Use as FM Signal Generator" paragraph).

b. Applying a specific fixed DC voltage will produce a specific output frequency (described in following "Programmed Frequency Selection" paragraph).

c. Applying a ramp voltage (or other type waveform if desired) provides externally controlled sweep generator operation (described in following "Use as Externally Controlled Sweep Generator" paragraph).

The following considerations apply to all modes of operation involving external control of the VCG (voltage-controlled generator):

1. The output frequency of the generator is determined by the voltage applied to the VCG. First of all, this voltage is established by the setting of the FREQ dial. Any voltage applied to the VCG IN jack is summed with the voltage from the dial setting. A positive voltage input drives the VCG to a higher frequency. However, the VCG can never be driven beyond its range limits (the highest and lowest frequencies that can be attained with the dial on a given range).

2. With the FREQ dial set at minimum (.002), and 0 volts at the VCG IN jack, the generator output frequency is at the lower limit of the selected range. Increasing the voltage to +10 volts drives the generator frequency to the upper limit of the range. Between 0 and +10 volts, the generator output frequency is proportional to the VCG IN voltage. The VCG IN voltage can be correlated to equivalent dial settings, as given in Table 2.

VCG IN Voltage (Volts)	Equivalent Dial Setting
0	.002
1	.2
2	.4
3	.6
4	.8
5	1.0
6	1.2
7	1.4
8	1.6
9	1.8
10	2.0

Table 2. Correlation between VCG IN voltage and equivalent dial setting (dial set to .002).

3. The FREQ dial is usually set to .002 when using external VCG control. This reduces the dialed VCG voltage to zero, and allows the external VCG voltage to exercise complete control. It also reduces the effects of dial setting inaccuracy.

4. If the summed dial setting and VCG IN voltage exceeds +10 volts, oscillation ceases and no output is produced. If the swing of the VCG IN signal is too great, oscillation will cease each time the instantaneous voltage reaches the limit.

Programmed Frequency Selection

A specific output frequency can be selected each time a specific VCG IN voltage is applied (assuming a common dial setting). Such operation may be advantageous where there is a requirement to return to a specific frequency

periodically. Set-up time is reduced by eliminating the need for frequency measurement and precision tuning each time the frequency is needed. Just set the dial against its lower stop and turn on the external VCG voltage.

A set of two or more specific frequencies may be programmed by using multiple DC voltages values which may be selected by a switch or electronic switching circuits. This type of operation would be desirable in production testing where signals at several specific frequencies are required for various tests. FSK (frequency shift keying) signals also may be generated in this manner.

To maintain the original accuracy each time the operation is repeated the FREQ dial must be accurately set to the same position. Probably the easiest way to assure this common dial setting is to set it against its lower stop (.002).

Additional information on programmed frequency selection is given in the APPLICATIONS portion of this manual.

Use as Externally Controlled Sweep Generator

A ramp voltage, or any other type waveform desired, can be applied for externally controlled sweep generator operation. A 0 to +10 volt swing will sweep frequencies over a 1000:1 ratio (with dial set to .002).

Set up the equipment as described for internally controlled sweep generator operation, except turn the SWEEP WIDTH control to OFF. Apply the sweep voltage with no DC component at the VCG IN jack. The amplitude of the external sweep signal will now determine the sweep width, and the frequency or repetition rate of the external sweep signal will determine the sweep rate.

One of the unusual variations possible in this mode is sweeping downward in frequency. Set the FREQ dial to the highest frequency to be swept and apply a negative-going ramp voltage.

EXTERNAL CONTROL OF TONE BURST GENERATOR

The Model 3020 may be operated as a tone burst generator using an external tone burst gating signal. The variation and precision of the repetition rate and tone burst width or duty cycle is limited only by the limitations of the external gating pulse generator.

Procedure

1. Set up equipment as described for internally controlled tone burst generator operation.

2. Set the EXT/INT switch to the EXT position (button out). The SWEEP RATE and BURST GATE controls now have no effect.

3. Connect the external tone burst gating signal to the GATE IN jack on the rear panel.

4. Adjust the external gating pulse generator to obtain the desired repetition rate and tone burst width or duty cycle.

Considerations

1. A TTL compatible external gating pulse signal is required at the GATE IN jack. Tone burst is produced when the gating pulse is at the logic 1 or high level of 2.0 volts or greater. The off period is produced when the gating pulse is at the logic 0 or low level of 0.8 volt or less.

2. An external variable gating pulse generator may be used for versatility. If a specific tone burst waveform is frequently required, an external gating pulse circuit with fixed time periods may reduce set-up time.

3. For some tests, a non-repetitive, manually commanded tone burst is desirable. This type of signal can be generated if the external gating pulse generator has a single-shot, pushbutton-actuated mode.

COMBINATION OF MODES

The Model 3020 may be operated in many of its modes simultaneously. For example, it may be operated with amplitude modulation and frequency modulation at the same time. This is useful for checking the effect of AM in an FM circuit in the presence of an FM signal. Following is the list of modes of operation that may be combined, if desired. In each of the combinations, sine, square, or triangle wave output may be used, and the output may be taken from the 50Ω or TTL output. Where sweep or tone burst modes are listed, either internally or externally controlled operation is equally applicable.

AM and FM.

AM and Sweep.

AM and Tone Burst.

AM and Sweep and Tone Burst.

AM with suppressed carrier and FM.

AM with suppressed carrier and Sweep.

AM with suppressed carrier and Tone Burst.

AM with suppressed carrier and Sweep and Tone Burst.

Pulse (includes all non-symmetrical square, triangle, or sine waves) and Sweep.

Pulse and Tone Burst – gated pulse train.

FM and Tone Burst.

FM and internally controlled Sweep.

Sweep and Tone Burst.

Sweep and tone burst operation can be obtained simultaneously, either internally or externally controlled. However, when both are internally controlled, the SWEEP RATE control affects both the sweep repetition rate and the tone burst repetition rate. If independent repetition rates are required, use external control for one or both functions.

APPLICATIONS

INTRODUCTION

Because of the great versatility of the Model 3020 Sweep/Function Generator, it would be impossible to include all of its possible applications in this manual. However, many of the primary applications are described in sufficient detail to allow the user to adapt the procedures to other applications. The instrument has vast numbers of applications as a signal source in electronics design labs, classrooms, service shops, and production facilities. It has an application wherever there is a need to test or analyze audio, radio, digital, communications, medical electronics, sonar, industrial electronics, subsonic, ultrasonic and many, many other electronic devices and circuits.

TROUBLESHOOTING BY SIGNAL SUBSTITUTION

When troubleshooting dead audio equipment, localize the trouble by injecting an audio signal from the Model 3020 Sweep/Function Generator to substitute for the normal signal. Starting nearest the speaker and moving toward the audio input one stage at a time, sound will be heard from the speaker for each stage that is operating normally. When signal is applied to the defective stage, no sound will be heard from the speaker. One precaution: make sure the DC offset matches the normal operating voltage at each point of signal injection. Improper DC offset could bias a normally operating stage to cutoff and make it appear defective. Improper DC offset could also damage certain circuits. A coupling capacitor may be used to block the DC offset and allow the signal to float at the DC level of the point of injection if desired.

The signal amplitude should also simulate the normal signal levels used in the circuit where signal is being injected.

This technique is equally applicable to non-audio equipment. Just connect an oscilloscope, voltmeter, or any other device which will indicate the presence or absence of output. Inject the type of signal normally used by the equipment being tested. The 3020 can generate almost any type of signal normally required in the .02 Hz to 2 MHz range.

If the equipment under test is already handling one or more signals that could be confused with the test signal, the Model 3020 can generate unique sounds or signals by means of sweep or tone burst operation that should be easily distinguishable from any other signals that may be present.

TROUBLESHOOTING BY SIGNAL TRACING

This technique is similar to "Troubleshooting by Signal Substitution" except that the signal is injected at the input of the equipment under test. An oscilloscope is then used to check for output at each stage, starting nearest the input and moving toward the output. The stage which has no output is presumed to be defective.

USING THE 3020 AS A BIAS AND SIGNAL SOURCE

In the test set-up of Fig. 10, the 3020 can be used to bias the transistor under test as well as to furnish an AC signal. By observing the amplifier output on the oscilloscope, the amplitude and bias of the transistor can be optimized for maximum undistorted output. By use of the DC OFFSET control, the effects of various types of bias (class A, B, and C) can be determined.

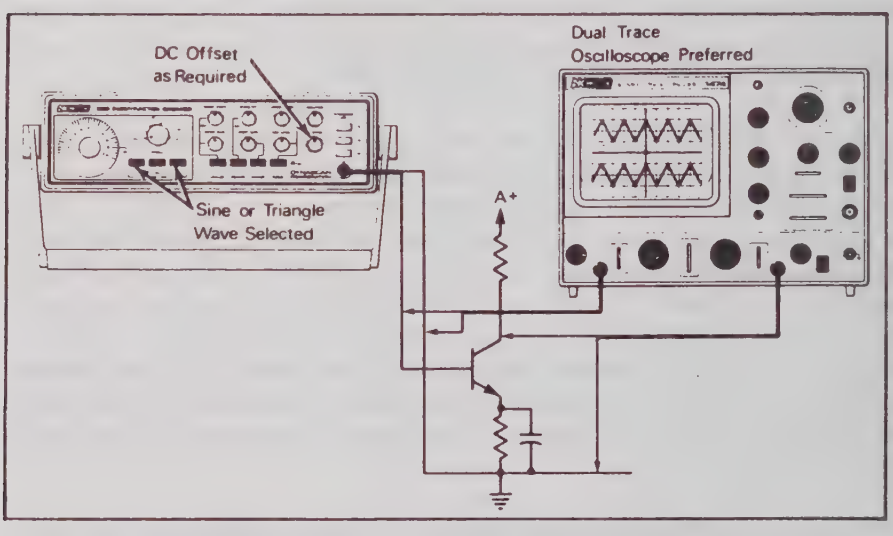


Fig. 10. Use of Model 3020 as a combined bias supply and signal source.

AMPLIFIER OVERLOAD CHARACTERISTIC

The overload point for some amplifiers is difficult to determine using sine-wave input. The triangle wave form is ideal for this type of test because any departure from absolute linearity is readily detectable. Using the triangle output, the peak overload condition for an amplifier can be readily determined. This overload condition is shown in Fig. 11.

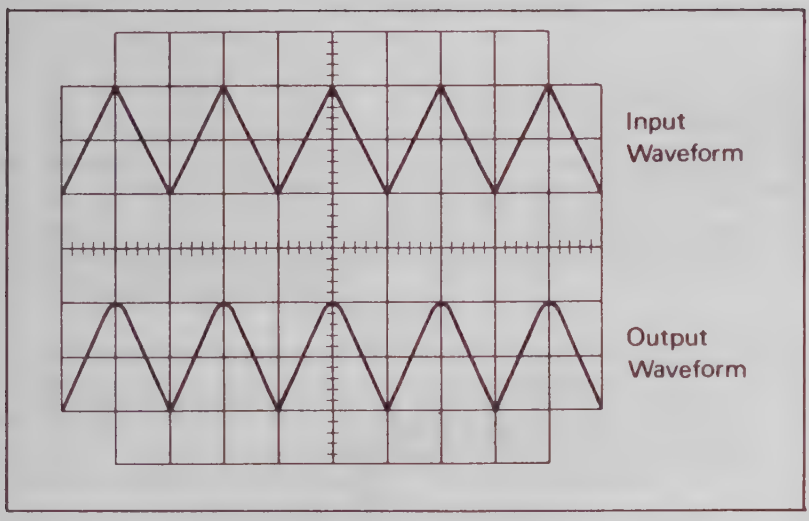


Fig. 11. Amplifier overload characteristics.

AMPLIFIER PERFORMANCE EVALUATION USING SQUARE WAVES

The standard sine-wave frequency response curves do not give a full evaluation of the amplifier transient response. The square wave, because of the high harmonic content, yields much information regarding amplifier performance, when used in conjunction with an oscilloscope.

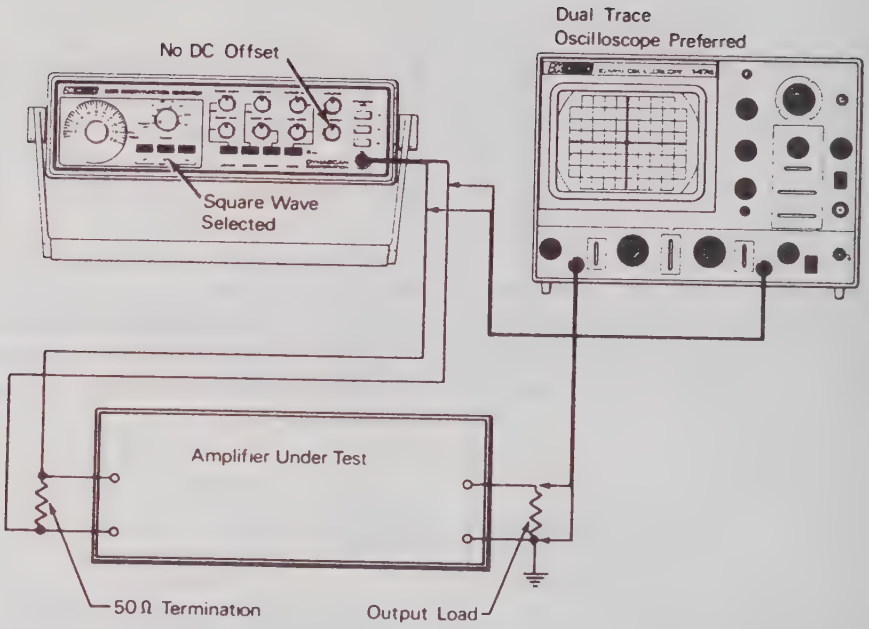
1. Use the test set-up of Fig. 12A. The 50-ohm termination at the amplifier input is essential when using square waves to eliminate the ringing effects generated by the fast rise times.

2. Using the triangle output of the 3020, set the AMPLITUDE control so that there is no signal clipping over the range of frequencies to be used.

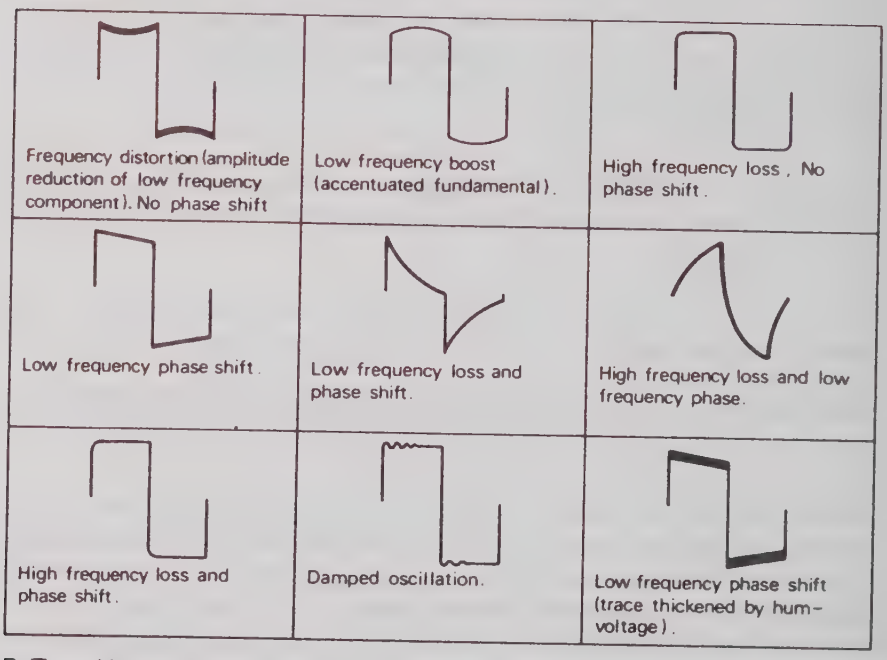
3. Select the square wave output and adjust the frequency to several check points within the passband of the amplifier, such as 20 Hz, 1000 Hz and 10 kHz.

4. At each frequency checkpoint the waveform obtained at the amplifier output provides information regarding amplifier performance with respect to the frequency of the square wave input. Fig. 12B indicates the possible waveforms obtained at the amplifier output and the causes.

Square wave evaluation is not practical for narrow-band amplifiers. The restricted bandwidth of the amplifier cannot reproduce all frequency components of the square wave in the proper phase and amplitude relationships.



A. Test Set-up


Frequency distortion (amplitude reduction of low frequency component). No phase shift
Low frequency boost (accentuated fundamental).
High frequency loss, No phase shift.
Low frequency phase shift.
Low frequency loss and phase shift.
High frequency loss and low frequency phase.
High frequency loss and phase shift.
Damped oscillation.
Low frequency phase shift (trace thickened by hum-voltage).

B. Test Waveforms

Fig. 12. Amplifier performance evaluation using square waves.

FREQUENCY RESPONSE MEASUREMENTS, LINEAR DISPLAY

(See page 64 for Linear/Log Display Method)

Introduction

The Model 3020 Sweep/Function Generator is ideal for checking the frequency response of such devices as amplifiers, bass and treble controls, bandpass filters, low or high pass filters, coupling networks, speakers and speaker enclosures, tuned circuits, notch filters, and any impedance network. This instrument provides the signal source for measuring, adjusting and analyzing the frequency response of any active or passive device up to 2 MHz.

It simplifies measurements with its internal sweep generator capability, or permits external sweep control for sine or special sweep patterns. Its 1000:1 sweep range allows the entire 20 Hz to 20,000 Hz audio spectrum to be covered in a single sweep. This is a major convenience compared to several measurements, each covering only a portion of the spectrum.

Test Set-Up

The following procedure, along with Fig. 13, describes the typical set-up and method for measuring frequency response:

1. Select the desired frequency range with the RANGE switch. Choose the range at which the *highest* frequency of the sweep would be selected if dialed in manually.

2. Set the FREQ dial to select the lowest frequency to be swept.

3. During initial set-up, turn the SWEEP WIDTH control to OFF.

4. Connect a cable from the GCV OUT jack to the horizontal or X input of the oscilloscope.

5. Set the oscilloscope for external horizontal or X-Y operation. A single dot should appear on the screen.

6. Select DC coupling for the horizontal or X input to the oscilloscope.

7. Use the oscilloscope position controls to locate the dot at a convenient reference point toward the right side of the screen.

8. Use a grease pencil or china marker and mark the location of the dot on the face of the oscilloscope screen.

9. Set the FREQ dial to the highest frequency to be swept. As the frequency is increased, the dot will move to the left.

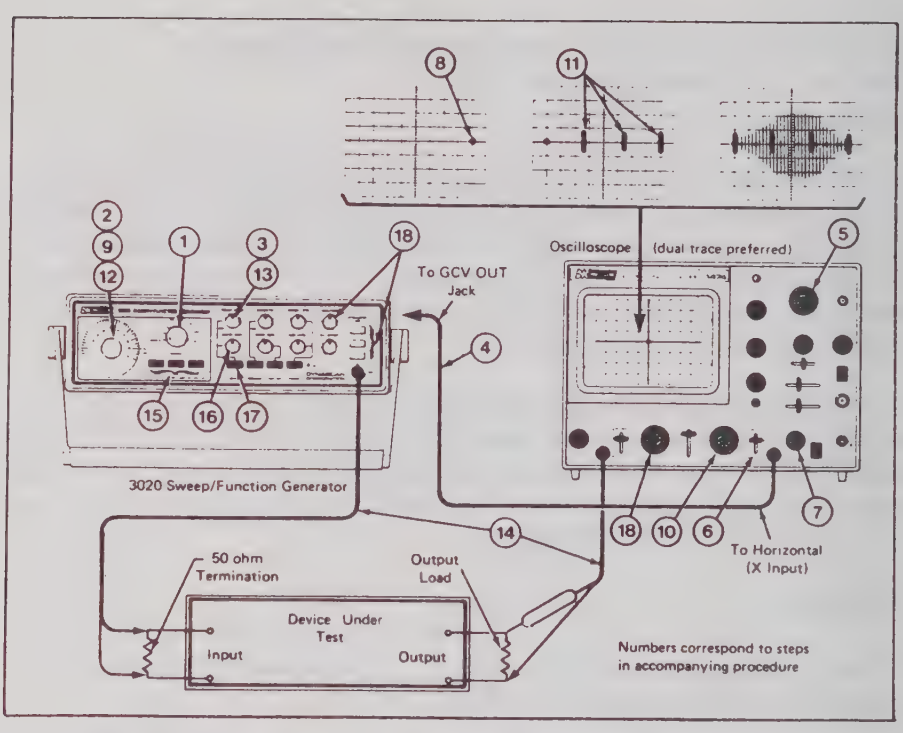


Fig. 13. Frequency response test set-up and measurement.

10. Use the oscilloscope horizontal gain control to position the dot at a convenient reference point toward the left side of the screen. Recheck steps 2 and 7 to make sure the gain control has not shifted the position of the dot at the lowest frequency. If necessary, readjust oscilloscope position controls and horizontal gain so that the low and high frequency dot positions are both at convenient reference points.

11. Mark the dot positions for the highest frequency to be swept on the screen with a grease pencil. Set the FREQ dial to any intermediate frequencies of interest at which markers are desired. Add markers on the face of the screen which correspond to each of these dial settings.

12. Now return the FREQ dial to the lowest frequency to be swept in preparation for sweep operation.

13. As the SWEEP WIDTH control is turned clockwise, a horizontal trace will develop on the oscilloscope screen. Set the SWEEP WIDTH control so that the trace exactly spans the space between the highest and lowest frequency markers on the screen. Do not readjust oscilloscope horizontal gain.

14. Connect the 50Ω output of the Sweep/Function Generator to the input of the circuit being tested. Connect a 50-ohm termination across the input terminals (not required if the input impedance is 50 ohms). Connect the output of the circuit being tested into its normal load impedance. Connect the vertical or Y input of the oscilloscope to measure the voltage across the output load of the circuit being tested.

15. Select sine, triangle, or square wave signal, as appropriate. Sine wave signal is most commonly used for frequency response checks.

16. Set the SWEEP RATE control as high as possible to minimize flickering of the oscilloscope display, but low enough to obtain a few cycles of signal at the lower frequencies of the sweep.

17. Either LIN or LOG sweep will produce a *linear display*. The LOG position is sometimes preferred because it does not sweep through the low frequencies as fast.

18. Adjust signal amplitude with the AMPLITUDE control and the ATTENUATION buttons. Set the vertical gain of the oscilloscope as desired for convenient viewing height of the oscilloscope display. Be sure to keep the signal below the clipping level of the circuit being tested. To assure against clipping start with a very low signal level and increase signal amplitude until the highest peak on the display no longer increases in height as the AMPLITUDE control is increased, then reduce amplitude slightly below that point.

The Frequency Response Display

When using a conventional oscilloscope probe, the display will be an envelope such as shown in Fig. 14. The relative gain or attenuation of all frequencies within the swept band is displayed. The display may be analyzed for acceptable or unacceptable frequency response characteristics. In wideband amplifiers, the objective is usually to maintain a flat frequency response over the widest possible bandwidth. Frequency response displays of filters and coupling networks show the cutoff frequency and the sharpness of the cutoff. The frequency response display is often the basis for alignment of RF circuits (Fig. 17 and 18). The display also may be analyzed to determine the center frequency of bandpass, symmetry of bandpass, bandwidth, gain or signal amplitude, Q, and rejection of adjacent frequencies.

Tone Control Test

If an audio amplifier under test is equipped with bass and treble controls, the effects of these controls on overall response can be determined by running frequency response tests while adjusting the controls throughout their range of adjustment. Fig. 15 illustrates some typical responses.

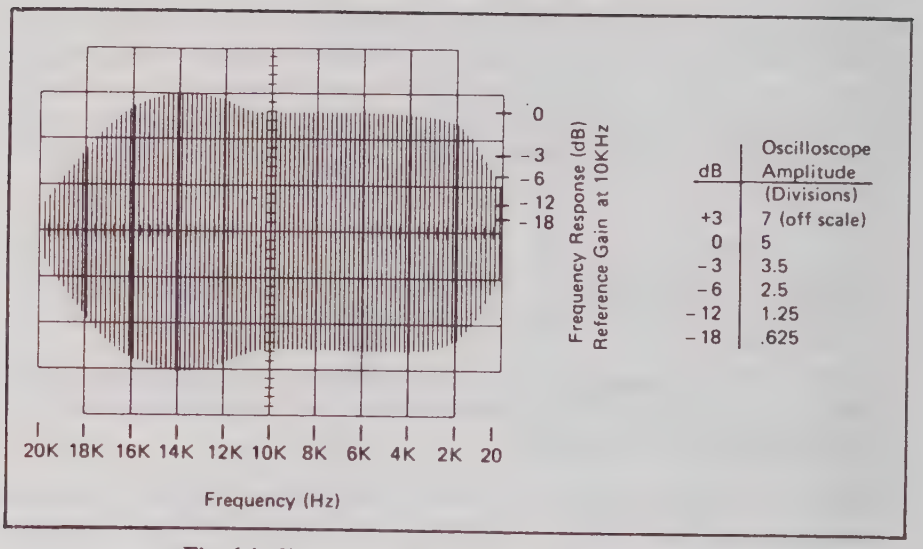


Fig. 14. Typical audio amplifier response display.

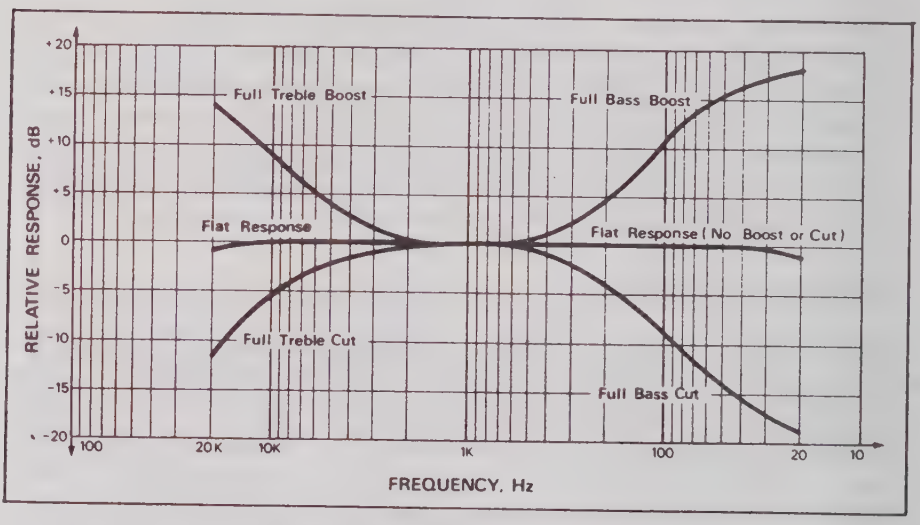


Fig. 15. Effects on audio frequency response by varying tone controls.

TESTING SPEAKERS AND IMPEDANCE NETWORKS

The 3020 can be used to provide information regarding the input impedance of a speaker or any other impedance network vs. frequency. In addition, the resonant frequency of the network can be determined.

1. Connect equipment as shown in Fig. 16A, or as for frequency response measurement except that the signal input to the speaker or impedance network is monitored. The oscilloscope may be used to verify that the 3020 is not in a clipping condition.

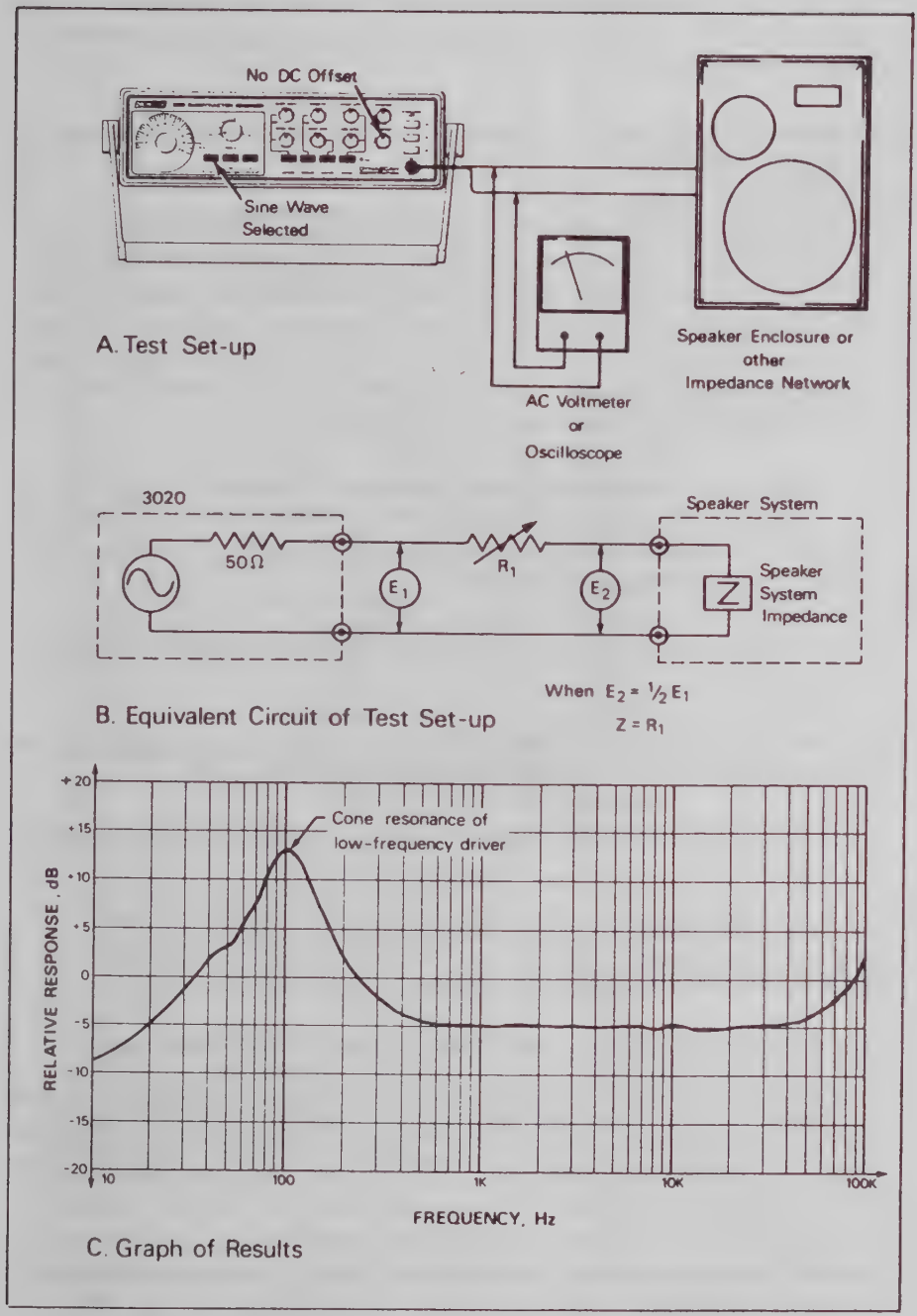


Fig. 16. Testing speaker systems and impedance networks.

2. If the voltmeter method is used, vary the 3020 over the full range of interest and log the voltage measured at the speaker terminals vs. frequency. The dB scales of the AC voltmeter are convenient for converting this information to standard response units.

3. If the oscilloscope method is used, use sweep operation as for frequency response measurement.

4. In speaker testing, a pronounced increase of voltage will occur at some low frequency. This is the resonance frequency of the speaker system (Fig. 16C). The speaker enclosure will modify the results obtained from the same speaker without an enclosure. A properly designed enclosure will produce a small peak on each side of the peak obtained without an enclosure. The enclosure designer can use the response characteristics to evaluate the effects of varying port sizes, damping materials, and other basic enclosure factors.

5. In testing other impedance networks, resonance will not necessarily occur at low frequency. However, as resonance is approached the signal level will increase. The impedance of the network can be measured at resonance, or at other frequencies if desired as follows:

   a. Connect a variable resistor in series with the impedance network as shown in Fig. 16B.

   b. Measure the voltage at points E1 and E2 respectively and adjust variable resistor R1 so that voltage E2 equals one half of voltage E1.

   c. The impedance of the network equals the resistance of variable resistor R1.

AM RECEIVER ALIGNMENT

1. Use the test set-up of Fig. 17, which will produce a linear sweep display.

2. If a precise center frequency and bandwidth is required, a frequency counter should be used during set-up. Before sweep operation begins, set the FREQ dial to obtain the desired frequencies of interest on the counter and place markers on the oscilloscope screen.

3. The signal can be injected either at the mixer (455 kHz) or at the antenna (up to 2 MHz). When injecting the 455 kHz signal at the mixer input, the local oscillator must be disabled.

4. When the IF response is observed at the input to the AM detector, an RF detector probe is required unless a demodulated point is specified by the manufacturer.

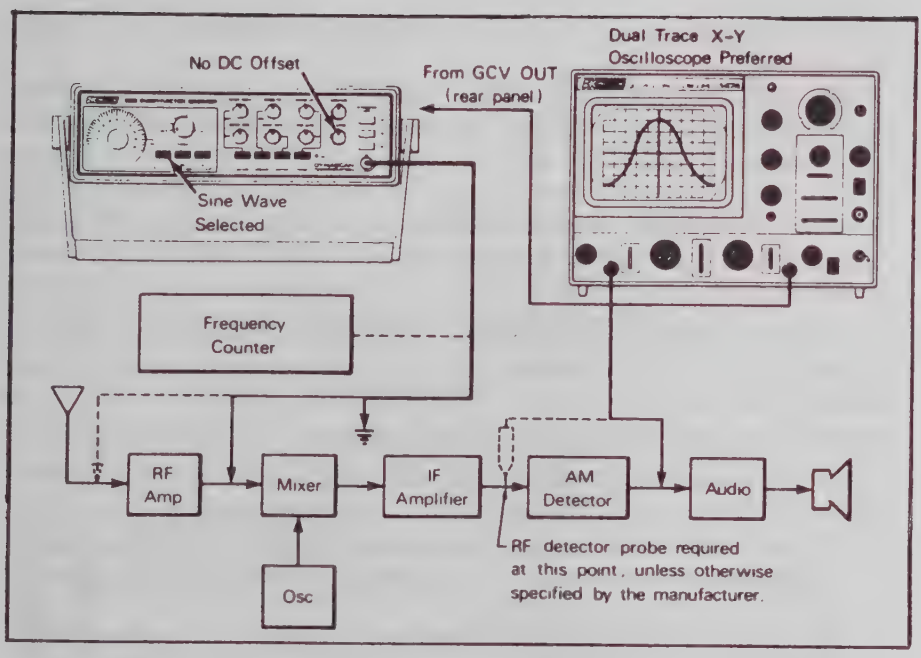


Fig. 17. AM receiver alignment.

5. The IF amplifier tuning adjustments can be performed as required to obtain the desired IF response curve. Normally each tuned circuit is adjusted for maximum amplitude at the IF center frequency.

External sweep may be used if desired for sine wave or other sweep patterns. Connect the external sweep voltage source to the VCG IN jack. The external sweep voltage should also be applied to the horizontal input of the oscilloscope. To set up frequency markers, a variable DC power supply fed into the VCG IN jack and oscilloscope horizontal input, and a frequency counter to measure output frequency may be used. However, even with external sweep operation, it may be more convenient in setting up frequency markers to use the GCV OUT voltage to drive the horizontal input of the oscilloscope, because it allows direct correlation between the oscilloscope display, frequency counter, and FREQ dial of the 3020.

FM COMMUNICATIONS RECEIVER ALIGNMENT

The test set-up of Fig. 18 can be used for alignment of FM communications receiver IF's and discriminators using the 455 kHz IF frequency. For accurate frequency adjustments, a 455 kHz crystal-controlled marker source should be used.

1. Use sweep operation and apply signal to the input of the 455 kHz IF section.

2. When signal at the output of the 455 kHz IF section is displayed, a response curve similar to Fig. 18A should be obtained. The marker "pip" should be in the center of the response curve.

3. When the output of the discriminator is displayed, a response curve similar to Fig. 18B should be obtained. The "S" curve should be balanced on each side of the marker "pip."

In some receivers the IF selectivity is "packaged," which means all adjustments are preset. In this case the receiver alignment can only be evaluated and verified without adjustment. Where the tuned circuits are adjustable, the manufacturer's procedure must be followed to insure that the proper overall response is obtained.

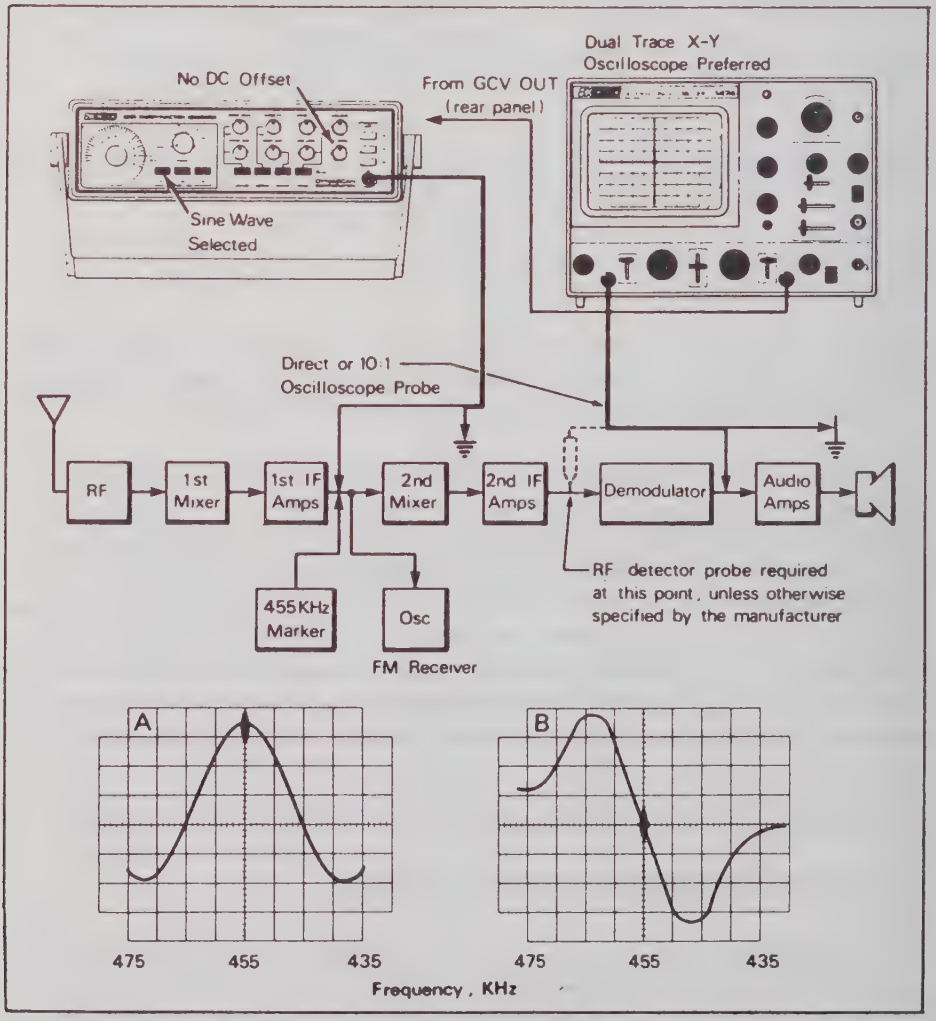


Fig. 18. Alignment of FM communications receiver IF's and discriminator.

TESTING DIGITAL LOGIC CIRCUITS

The 3020 is well-suited for testing digital logic circuits. It can supply square waves, pulses, or a gated pulse train, and any of these waveforms may be swept in frequency if desired. It can supply clock pulses for breadboarding and design analysis. Effects of varying pulse frequency, waveshape, and DC offset can be analyzed. It can provide the correct digital drive signals to circuit boards that are removed from a system. It can drive quiescent equipment into a dynamic condition for testing. In troubleshooing digital logic circuits, it can provide the proper signals for the signal tracing or signal substitution method of fault isolation.

1. Connect the equipment as shown in Fig. 19.

2. Set up the 3020 to generate square waves, pulses, or a gated pulse train as described in the "Operating Instructions" portion of the manual. For a gated pulse train set up the pulses first, then set up the gating as described for tone burst operation. An external timing pulse applied at the GATE IN jack may be used for gating the pulse train if desired.

3. For testing TTL logic circuits, use the TTL OUT signal. The amplitude and DC offset are preset for direct injection without the need for set-up adjustment. Polarity of the TTL output is not reversible. A reverse polarity signal may be set up readily by simultaneously applying the TTL OUT signal and the 50Ω signal to the two channels of a dual trace oscilloscope. Adjust the AMPLITUDE and DC OFFSET controls so that the 50Ω output exactly matches the TTL OUT signal displayed on the oscilloscope. Polarity of the 50Ω output can now be reversed at will with the NOR/INV switch.

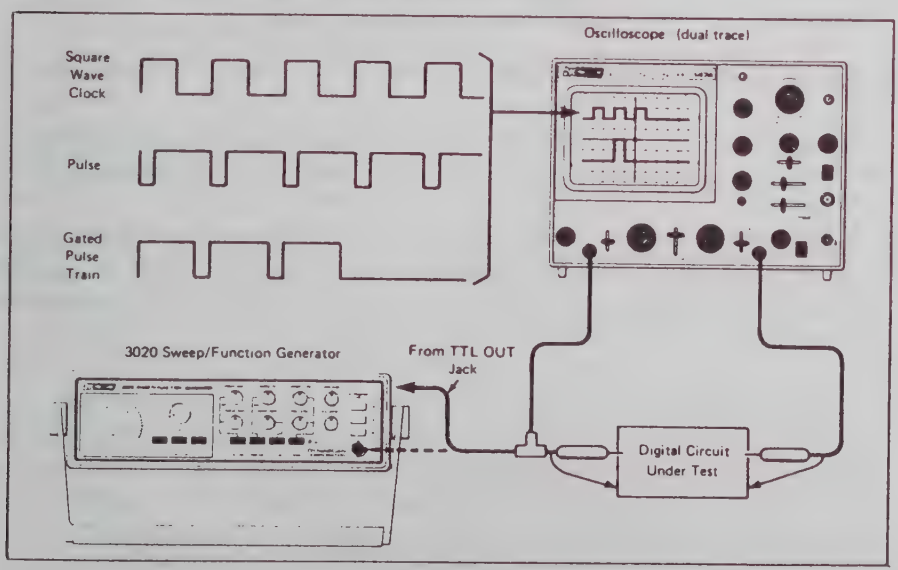


Fig. 19. Testing digital logic circuits.

4. For CMOS, negative logic, or any other variation from standard TTL logic, use the 50Ω output. Display the signal on the oscilloscope and adjust the AMPLITUDE and DC OFFSET controls as required to obtain the correct waveform before applying the signal to the circuit under test. A coupling capacitor may be used to block the DC offset from the circuit under test if desired.

5. Timing relationships between the input signal and other points in the circuit are usually of primary interest in digital circuits. A dual-trace oscilloscope allows both signals to be displayed simultaneously for this time relationship comparison.

TESTING TONE BURST DECODERS

A tone burst decoder requires a specific tone frequency, such as 2250 Hz, for a specific minimum period of time, such as 120 milliseconds, before it will provide an output. The delay prevents voice signals or other random on-frequency signals from falsely activating the decoder. Using the tone burst mode of operation, the 3020 can generate the signals necessary to test the delay time, as well as the frequency response and sensitivity, of tone burst decoders.

The following procedure, along with Fig. 20, describes the typical testing method for tone burst decoders:

1. Connect equipment as shown in Fig. 20. Set the RANGE switch and FREQ dial to the decoder's acceptance frequency. This should be found in the manufacturer's service literature, or may be marked on the unit. Use a frequency counter if a high degree of accuracy is required.

2. Set the burst gate INT/EXT switch to INT.

3. Using the BURST GATE control, adjust the duration of the tone burst to equal or slightly exceed the specified turn-on delay time of the unit under test.

4. Adjust the repetition rate of the tone burst with the SWEEP RATE control. Allow plenty of time between tone bursts for the decoder to fully return to its standby condition. The repetition period may also be measured on the oscilloscope.

5. Using a dual-trace oscilloscope in its chop mode, display the decoder input signal on one trace and the decoder output on the other trace. The decoder's turn-on delay period can be measured on the oscilloscope. This is the time period from the beginning of the tone burst (synchronize the scope to the tone burst signal) until the decoder output changes states. Decoder turn-off delay can also be measured. This is the time period from the end of the tone burst until the decoder output reverts to the off state.

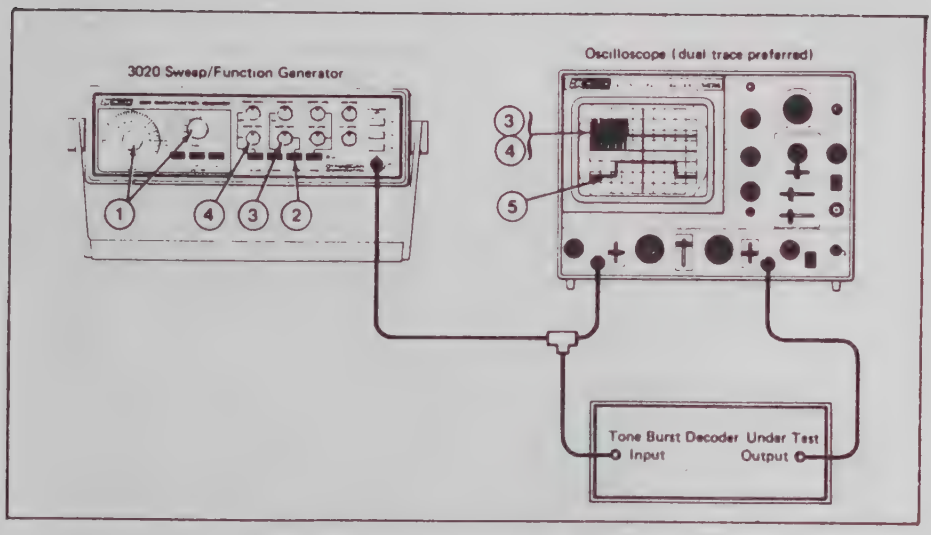


Fig. 20. Tone burst decoder testing.

6. Decoder sensitivity can be measured by varying the amplitude of the tone burst signal. Adjust the amplitude to the level that will barely activate the decoder output. Measure this signal level; it is the decoder's threshold sensitivity.

7. Alignment and off-frequency rejection may be checked by performing a frequency response measurement on the tone burst decoder. Measure the output of the decoder tuned circuits, before the detector.

TESTING MODULATION LIMITERS AND COMPRESSION AMPLIFIERS

Compression amplifiers are often used in communications equipment to provide better audibility over a wide range of input conditions. One very common application is modulation limiting in CB radio transmitters. Attack time, the time delay from initial application of signal until full compression takes effect, is a primary consideration in compression amplifiers. In CB transmitters, it is expected to become a factor of FCC compliance. The tone burst output of the Model 3020 Sweep/Function Generator provides an effective method of testing attack time. Attack time *cannot* be measured with continuous signal applied.

1. Connect equipment as shown in Fig. 21. Using a dual-trace oscilloscope in its chop mode, display the input of the compression amplifier on one trace and the output on the other trace.

2. Place the Model 3020 Sweep/Function Generator in the tone burst mode of operation.

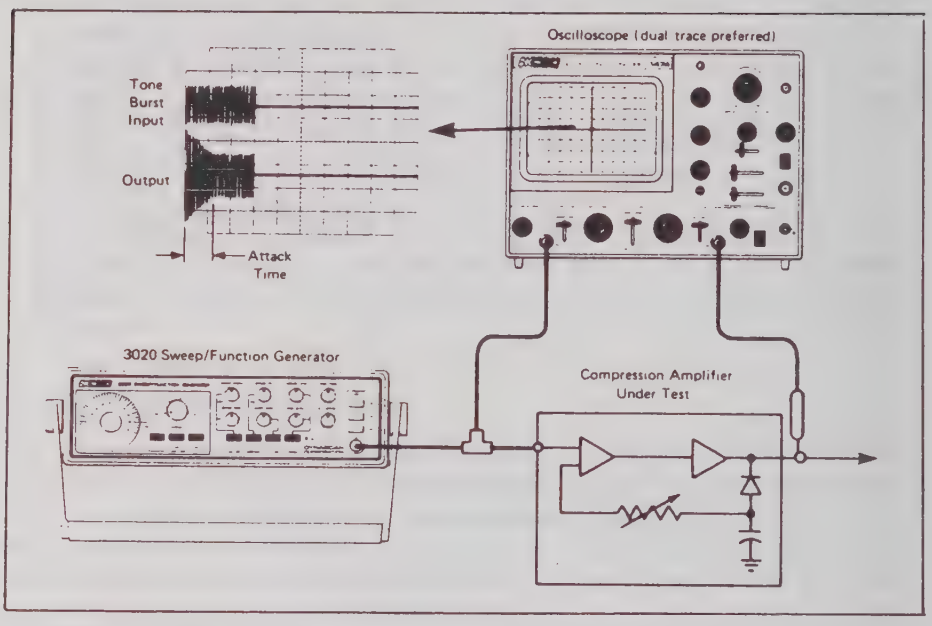


Fig. 21. Measuring attack time of compression amplifier.

3. Observe the output wavefore on the oscilloscope. Note that the amplitude of the waveform is maximum at the beginning of the tone burst, and decreases until full compression takes effect. At that point, the amplitude becomes constant.

4. Allow enough tone burst width for full compression to take effect. Allow plenty of time between tone bursts for the bias of the compression amplifier circuit to revert to the full gain state.

5. Using a calibrated time scale on the oscilloscope, measure the attack time, as shown in Fig. 21 and compare with the manufacturer's specifications.

6. The effectiveness of the compression amplifier also may be tested by applying various amplitude input tone bursts and measuring the output amplitude. Specifications for compression amplifiers are often stated in this manner. For example, "30 dB variation in input level will produce no more than 3 dB variation in output level."

7. Testing may be performed at various frequencies of the compression amplifier's passband.

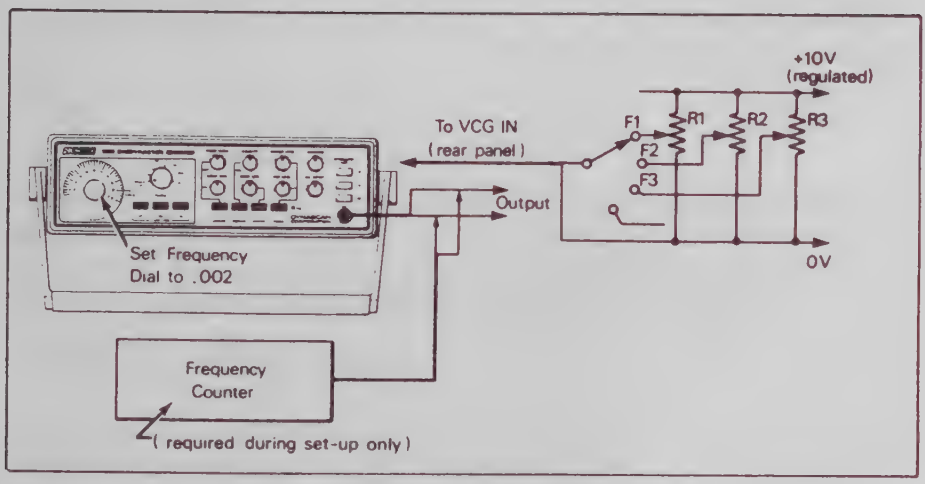


Fig. 22. Preset frequency selection.

PRESET FREQUENCY SELECTION

In test and design work where several frequencies are used repeatedly, it is convenient to be able to preselect these frequencies with a minimum of effort. As shown in Fig. 22, the VCG feature of the 3020 can be used together with preset voltages and a frequency selector switch.

1. Set the FREQ dial of the 3020 to .002.

2. Connect the 50Ω output to a frequency counter.

3. With the frequency selector switch in the F1 position, adjust R1 for the desired frequency as observed on the frequency counter. Repeat this for the frequencies desired.

4. With the FREQ dial set at .002, and a maximum available A+ voltage of about 10 volts, frequencies encompassing a 1000:1 range can be obtained by this method on each frequency range.

5. To maintain frequency accuracy each time the set-up is used, the dial must always be set to exactly the same position. To assure this accuracy, set the dial solidly against the low end stop at dial setting .002.

DIGITAL FREQUENCY SELECTION

Frequencies can be switched electronically by using the set-up shown in Fig. 23. The preset voltages can be digitally selected and applied to the VCG IN

jack on the Model 3020. Although provision for two frequencies are shown, additional frequencies can be added using redundant circuits. This is convenient in frequency shift keying (FSK) systems.

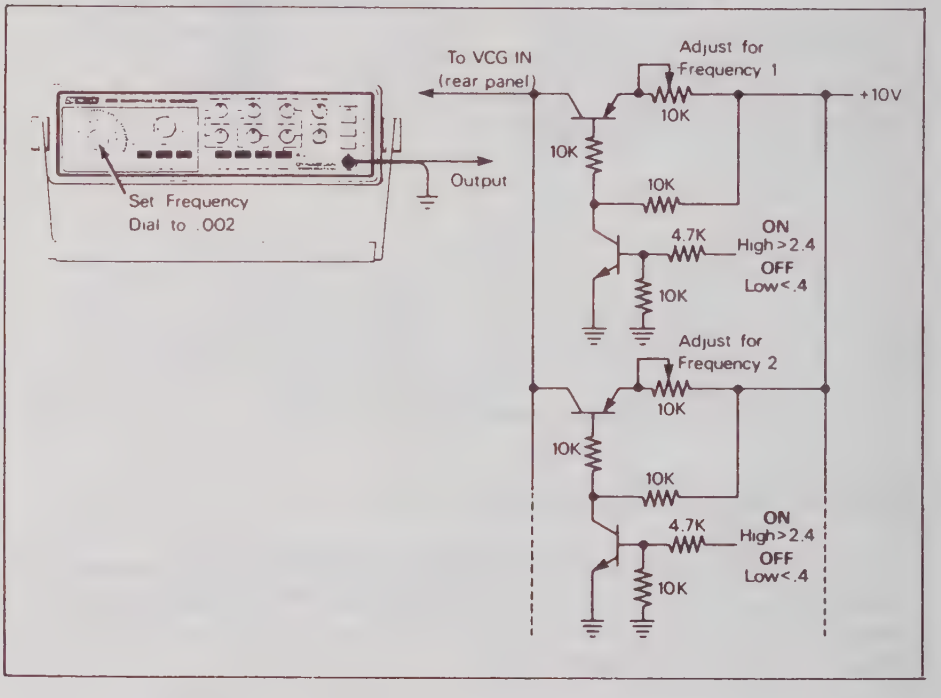


Fig. 23. Digitally programmed frequency selection.

ADDITIONAL APPLICATIONS

The triangle or ramp output of the 3020 can be used at its lowest frequencies to simulate a slowly varying DC source. This can be used to check threshold levels of TTL and CMOS logic as well as voltage comparators. Chart recorders can be checked by this method. Analog meter movements can be exercised from zero to full scale to observe defects, such as sticky meter movements.

THEORY OF OPERATION

The block diagram, Fig. 28, is located at the rear of this manual on a fold-out page that may be unfolded and used for reference while reading the associated text which follows. The block diagram defines the circuit breakdown of the generator. Refer to the separately supplied schematic diagram for circuit details.

GENERAL CIRCUIT DESCRIPTION

The basic waveform generated in the Model 3020 is the triangle wave. This is accomplished by charging and then discharging a capacitor by equal magnitude currents. A dual comparator and flip-flop determine whether the capacitor is being charged or discharged. When the voltage on the capacitor reaches the positive limit, the charging current is switched off and the capacitor discharges until the lower limit is reached at which time the charging current is then reapplied. The output of the dual comparator is a square wave.

To produce a sine wave, the triangle wave is shaped by a special amplifier. Range switching is accomplished by changing the magnitude of the current sources and the timing capacitors. Dial frequency tuning is done by changing the magnitude of the current sources. A frequency change of over a 1000:1 is possible with the frequency dial.

The peak-to-peak voltage of the triangle wave generated is 2.0 volts. the frequency of operation is determined by the currents, the capacitor value and the peak-to-peak voltage of the triangle wave.

DETAILED CIRCUIT DESCRIPTION

Frequency Control Voltage Reference (IC1A)

The frequency control voltage reference is composed of five trimpots (R2 thru R6), two resistors and IC1A, which divide the +15 volts supply and provide a reference voltage of approximately +10 volts to the FREQ dial potentiometer. Each trimpot is adjusted to compensate for the tolerance variations of the timing capacitors.

Tuning Amplifier (IC1B)

The tuning amplifier is provided to buffer the output of the FREQ dial pot. This assures that this voltage will be as linear as frequency pot R3 itself. If not, R9 would be in parallel with frequency pot R3 and the action of the frequency pot would be non-linear.

Current Summing Amplifier (IC1C, Q2)

The current summing amplifier sums the current from the tuning amp, VCG IN jack, and sweep generator. The current from the tuning amp is simply the voltage at its output divided by the value of R9 (1K). The current from the VCG IN input is normally zero. When a voltage is applied, the current into the summer is the voltage divided by R11 (1KΩ). For a 1000:1 sweep, the voltage has to be approximately +10 V. The output current (collector of Q2) creates a voltage across R18 (1K) that tracks the voltage of the tuning amplifier.

Current Source Driver (IC2, Q3)

Q3 is a FET driver used in conjunction with the operational amplifier IC2. IC2 and Q3 are connected as a voltage follower with a closed loop gain of +1. The voltage at the source and drain of Q3 follow the input voltage of pin 3 but are of opposite polarity. In this way the current source driver provides both current sources with equal voltages.

Positive and Negative Current Sources (IC3, Q4, IC4, Q5)

The current sources provide two switchable sets of currents. IC4 and Q5 are connected as a voltage follower. The voltage at the drain of Q5 is equal to the voltage at the input to IC4 (pin 3). The current produced, -I, is equal to the -15 volt supply minus the voltage at the drain of Q5, divided by the total resistance R_{T1} (which equals R31). The current -10I is produced by the same voltage but R32 has been switched in parallel with R31 and the total resistance is now the parallel combination R_{T10} (R32 in parallel with R31).

The voltage across R21 + R22 is equal and opposite to the voltage across R24, IC3 and Q4 are connected as a voltage follower similar to IC4 and Q5. The voltage at the source of Q4 is equal to the voltage at the input to IC3 (pin 3). The current produced is equal to the +15 volt supply minus the voltage at the source of Q4 divided by the total resistance R_{T2} (which equals R29). The value of R_{T2} is half the value of R_{T1}, therefore the current is 2I. Similarly, when R30 is switched in parallel with R29, the total resistance is R_{T20}. The total current with R_{T20} is 20I.

Diode Gates (D4, D5)

The diode gates are silicon diodes D4 and D5. In the 1 and 10 ranges, the positive current source puts out 2I and the negative current source sinks -I current. The purpose of the gates is to either switch the output of the positive current source to the capacitors to charge them, or to shunt the positive current so that the negative current source can discharge the capacitors. The gates work as follows:

1. If the signal from the dual-level detector and flip-flop is high-level TTL, +5 V, it reverse-biases diode D5 and cuts it off. Diode D4 now becomes forward-biased and all the current (2I) flows through D4. The negative current source is

also operating, but can only sink -I current. A net positive current, I, is seen by the capacitors and they are linearly charged by the constant current source to produce a positive ramp.

2. If the signal from the dual-level detector and flip-flop is low-level TTL, 0 V, it forward-biases diode D5 and the level detector sinks all the current (2I) from the positive current source. Diode D4 now becomes reverse-biased and no current flows thru it. The capacitors now see only the negative current source with -I current and are linearly discharged to produce a negative ramp. In the 100 through 1M ranges the gates work exactly the same except that the currents are now 10 times greater.

Timing Capacitors (C_T)

Timing capacitors C5 through C9 are chosen for such highly desirable qualities as:

1. Low dissipation factor.

2. Low temperature coefficient.

3. Long-term capacitance stability.

C_T Buffer (Q6, Q7)

The C_T buffer has a very high impedance to minimize leakage currents and prevent loading of the timing capacitors. Q6 is a dual FET; one half is the high-impedance buffer to the capacitors while the other half provides temperature compensation to the first half. Q7 is an emitter follower and is used to provide the necessary current to drive the level detector, sine shaper, etc. The three silicon diodes along with the base-emitter junction of Q7 shifts the triangle waveform seen at the emitter of Q7 up to four diode drops (about 2.5 V) so that the diode gates can switch properly with a TTL level signal from the level detector.

Dual-Level Detector and Flip-Flop (IC5)

The level detector senses the level of the ramp input (either positive or negative) and switches output states when the input reaches any one of two voltage limit references. The device (75107) has a dual differential input comparator stage and a dual three-input NAND gate output stage connected as an R-S flip-flop. The input limit voltage references are set by two voltage dividers on the tracking +15 V and -15 V supplies. Resistors R33 and R34 set +1.0 V for the minus input of one comparator. Resistors R38 and R39 set -1.0 V for the plus input of the other comparator. C12 couples a small positive feedback from one output of the line receiver (pins 5 and 9) to the inputs (pins 2 and 12) to speed up the switching.

TTL Buffer (IC6A, IC6B)

IC6A and IC6B are half of a quad NAND gate package. They are connected in parallel and provide a fan-out of 20 for the TTL square wave. This avoids any loading on the level detector.

Square Wave Level Shifter (IC6C, IC6D)

The square wave level shifter shifts the DC level of the TTL output of the level detector so that it is approximately symmetrical about zero. IC6C and IC6D are connected in parallel. One set of inputs (pins 2 and 12) are switched so that the level shifter operates only when the square function button is pushed on. Trimpot R46 provides an amplitude adjustment for the square wave.

Sine Wave Shaper (IC13)

The sine wave shaper takes a triangle wave input and non-linearly shapes it to produce a sine wave. The shaper utilizes the non-linear relationship of a differential transistor pair. The output is taken from one collector of the pair and buffered and level-shifted by the two other transistors in IC13. Trimpot R86 adjusts the amplitude of the sine wave and R100 adjusts its DC level at the output. Trimpots R88 and R94 are adjusted to provide the lowest distortion of the sine wave.

Output Amplifier (Q201 through Q205)

The output amplifier consists of a differential input stage (Q102 and Q202), followed by a common emitter transistor, Q203. The output from Q203 is applied to a push-pull output stage (Q204 and Q205). Feedback is applied from the output to the base Q202 by R207 and R208. The closed loop gain is approximately 10. DC offset is obtained by applying the offset voltage to the base of Q202 also.

Step Attenuator

A 3-step, pushbutton selectable, 50-ohm attenuator is provided between the output amplifier and the 50-ohm output jack. The series arrangement of 10 dB, 10 dB, and 20 dB sections makes all selected attenuation cumulative for 10 dB steps from 0 to −40 dB.

Sweep Circuits

A linear range waveform from IC7a, or a logarithmic ramp waveform from IC8a is selected by LIN/LOG switch S3. If the SWEEP WIDTH switch is on, this ramp voltage is summed with any output of tuning amplifier IC1b and VCG IN voltage to control the frequency of the generator. SWEEP WIDTH control R10 adjusts the amplitude of the sweep ramp voltage into the summing network.

The linear sweep ramp voltage waveform is also shaped into a pulse which becomes the tone burst gate.

Linear Sweep Generator (IC7a, IC7b, Q9)

Operational amplifier IC7a, capacitor C14 and resistor R57, develop a positive-going linear ramp voltage. The charge rate for C14, and thus the frequency of the ramp waveform, is adjustable by SWEEP RATE control R56. Operational amplifier IC7b switches, as does Q9, when the ramp voltage reaches the threshold of IC7b. This discharges capacitor C14 quickly, and forms the negative-going fall time of the ramp waveform.

Log Sweep Shaper (IC7c, IC8b, IC9a, IC8a)

Operational amplifier IC7c drops the level of the linear ramp waveform to appropriate levels to drive the shaper circuits. Logarithmic shaping is performed by IC8b and IC9a. The proper output level is provided by current-to-voltage converter IC8a.

Tone Burst Circuits

The internal tone burst generator uses the linear sweep generator ramp waveform as the basis of its timing. One cycle of sweep voltage ramp waveform becomes one cycle of tone burst gate pulse (tone burst and rest time). The BURST GATE control adjusts the proportion of tone burst time to rest time.

The internal or external tone burst gate is synchronized with the triangle wave signal so that the tone burst always starts and stops at the zero crossover point of the output waveform. Thus, there will always be full cycles or half cycles of signal in a tone burst. This is important for proper synchronization of an oscilloscope for measurements and testing using tone burst operation. The tone burst generator shunts the charging current from the timing capacitors to inhibit output during the rest time period of tone burst operation. The shunting action is removed during the tone burst, and output signal is permitted.

Schmitt Trigger (IC7d)

Differential amplifier IC7d effectively operates as a Schmitt trigger to produce a pulse from the linear ramp waveform. Threshold voltage is adjustable by the BURST GATE control, thus varying the width of the pulse.

Burst Gate Level Shifter (IC9d)

The pulse output from IC7d is shifted to TTL levels by IC9d for proper operation of the following gates. The INT/EXT switch selects the output of the burst gate level shifter in the INTernal position, or the GATE IN jack in the EXTernal position.

Inverter (IC11a)

The positive (logic 1) tone burst pulse is applied to IC11a, which OR's the

internal or external gating pulse and inverts to provide the necessary polarity to the dual comparator.

Zero Crossover Detector (IC10)

The triangle wave signal from C_t buffer Q7 is applied to both sides of zero crossover detector IC10. One side of the detector produces a clock pulse at zero crossover of the positive-going portion of the triangle wave. The other side produces a clock pulse at zero crossover of the negative-going portion of the triangle wave.

Dual Comparator (IC12a, IC12b)

The dual comparator consists of two type D flip-flops. The tone burst gate pulse is applied to the D input of both flip-flops. At the end of the tone burst, when the gating pulse changes states, output is delayed until the next zero crossover clock pulse. One of the comparators will then change states. Since the outputs are OR'ed by IC11b, and paralleled to Q11, either comparator will start shutdown of the output signal.

C_t Shunt Switch (IC1d, IC11b, Q10)

The outputs of both sides of the dual comparator are OR'ed by IC11b and applied to Q10. During tone burst, Q10 is off. During rest time it is on, and shunts the charging current from the timing capacitors. This inhibits the generation of an output signal. The timing of the dual comparator initiates inhibit when the timing capacitors are at the zero crossover point. The proper DC offset is provided by IC1d. Since the timing capacitors are held at the zero crossover point during inhibit, operation resumes at the zero crossover point when the inhibit pulse is ended.

Burst Gate Switch (Q11)

In addition to the inhibit provided by the C_t shunt switch, Q11 inhibits the dual-level detector and flip-flop during the same period by shifting its bias.

AM Modulation (IC201)

When the CW/AM switch is placed in the AM position, the output signal is first routed through modulator IC201. The output amplitude of the modulator is determined by the DC voltage reference set by the CARRIER LEVEL control, and the instantaneous modulating voltage applied at the AM IN jack. The MOD LEVEL control selects 0 to 100% of the AM IN voltage to be applied to IC201. The output is an amplitude-modulated signal with adjustable (suppressable) carrier level.

AM Level Shifter (Q206, Q207)

Since the output of IC201 operates at a positive DC reference, Q206 and Q207 shift the DC reference to zero. Buffer Q206 also provides impedance matching for a low-impedance output.

Power Supply (IC14, IC16, Q12, Q13)

Power transformer T1, bridge diodes D12-D15 and filter capacitors C18 and C19 generate +22 V and -22 V, unregulated. The +22 V is applied to voltage regulator IC14, which generates the +15 V supply. The +22 V also is applied through R107 to regulator IC15, which generates the +5 V. IC16B and Q13 comprise a -15 V regulator which is referenced to the +15 V via R14 and R115. In a similar manner, IC16A and Q12 comprise a -5 V regulator which is referenced to the +5 V supply via R111 and R112.

MAINTENANCE AND CALIBRATION

WARNING

1. The following instructions are for use by qualified personnel only. To avoid electric shock, do not perform servicing other than contained in the operating instructions unless you are qualified to do so.
2. A shock hazard is present when the case is removed once the line cord is plugged into an AC outlet. Avoid touching the fuse or bottom of the circuit board in the area of the fuse or power transformer. The fuse has 120 VAC (240 VAC on export models) on it even when the POWER switch is off.

REMOVAL OF REAR CASE

To remove the rear case from the generator, proceed as follows:

1. Use a coin (a quarter works best) to remove the two screws that hold the handle to the case. Use caution to avoid losing the springs beneath the screws that hold the handle on the case. Remove the handle. The handle may be reversed if the user desires. Refer to Fig. 24.
2. Remove the two Phillips-head screws from the rear case.
3. Slide the rear case from the generator.
4. Place the instrument on an insulated surface if power is to be applied with the case removed, such as during servicing and adjustment.
5. To reinstall the rear case on the generator, reverse the above procedure. Be sure the main circuit board slides into the slots inside the case.

LINE VOLTAGE CONVERSION, EXPORT MODELS

The 105-130 volt, 60 Hz power transformer (065-140-9-001), used in the 3020 standard models is replaced by a 105-130/210-260 volt, 50/60 Hz transformer

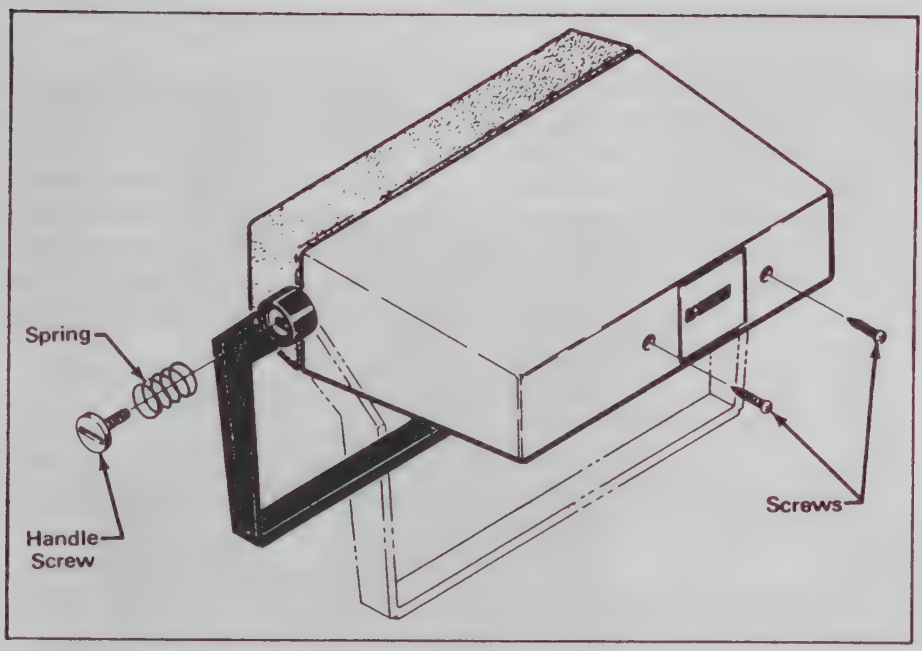


Fig. 24. Removal of rear case.

(065-140-9-002) for the export models. This tranformer is prewired to match the power source in the country of original sale. The transformer can be rewired to the alternate line voltage (see Fig. 25).

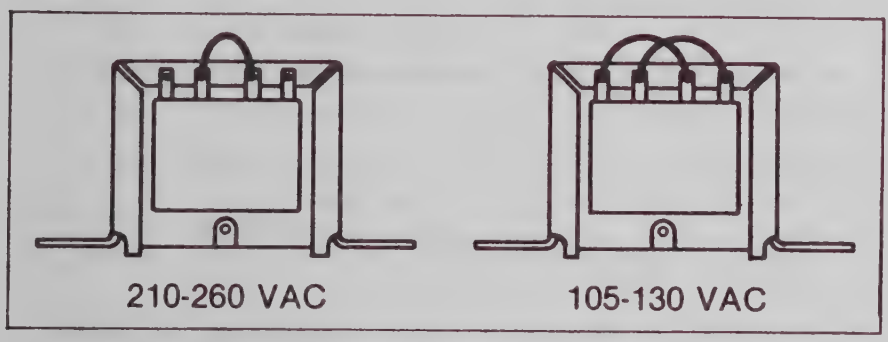


Fig. 25. Transformer wiring, export version.

FUSE REPLACEMENT

The AC line power fuse F1 should not open unless some defect has developed in the instrument. Replace the fuse *only* after investigation of the reason for its opening. Refer to Fig. 26 for fuse location on the main circuit board.

CALIBRATION ADJUSTMENTS

This unit was carefully checked and calibrated at the factory prior to shipment. Readjustment is recommended only if repairs have been made in a circuit affecting calibration, or if you have reason to believe the unit may be out of calibration. Complete recalibration procedures are given in this manual. However, calibration adjustments should be attempted only if the proper test equipment is available, and you are experienced and qualified in its use. If the accuracy of the test equipment used for calibration is less than specified, the accuracy of the 3020 will be proportionately degraded. Perform related adjustments in the specified sequence to avoid any undesirable interaction of adjustments.

Test Equipment Required

1. **DC Voltmeter.** 100 millivolt or 10 millivolt range; 1% of reading, ±0.2% of full-scale accuracy or better on 100 millivolt range (**B & K-PRECISION** Model 2810 or 2830).

2. **Frequency Counter.** 10 ppm time base or better, 200 Hz to 2 MHz (**B & K-PRECISION** Model 1820 or equivalent).

3. **Distortion Analyzer.** (Hewlett-Packard Model 331A or equivalent).

4. **Oscilloscope.** Any model **B & K-PRECISION** oscilloscope or equivalent.

Initial Set-Up Conditions

At the beginning of each calibration adjustment procedure, the controls of the 3020 should be set as follows:

- RANGE switch to 1kHz
- SWEEP WIDTH control to OFF
- SYMMETRY control to CAL
- NOR/INV switch to NOR
- EXT/INT switch to EXT
- CW/AM switch to CW
- No attenuation (ATTENUATOR buttons all out)
- 50Ω output jack terminated into 50-ohm load
- No connections to rear panel jacks
- All other controls to any position

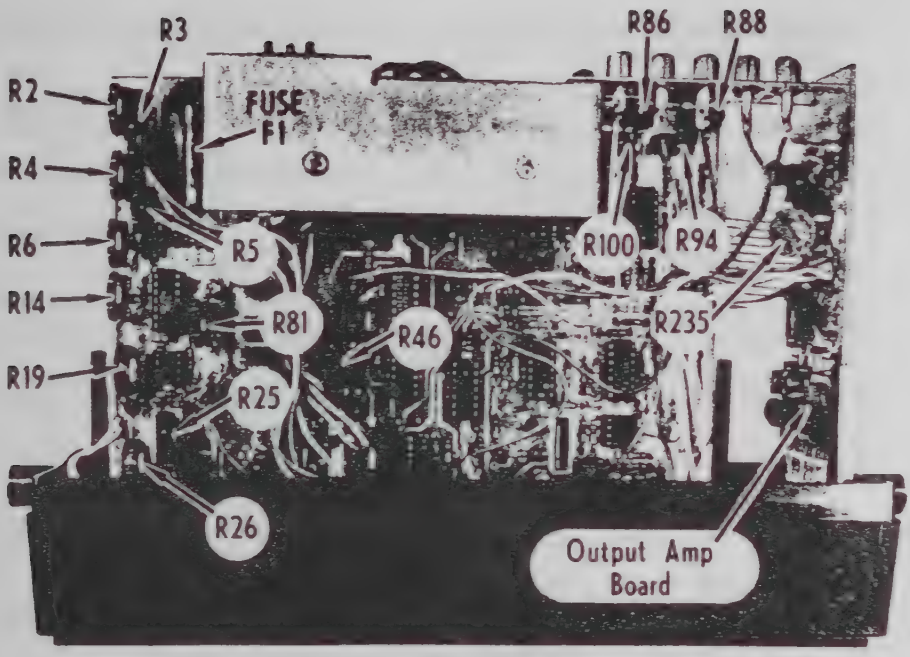


Fig. 26. Location of fuse and calibration adjustments.

Calibration Adjustment	Function	Calibration Adjustment	Function
R2	100 Hz range frequency	R26	Negative current balance
R3	1 kHz range frequency	R46	Square wave amplitude
R4	10 kHz range frequency	R81	C_t shunt DC level
R5	100 kHz range frequency	R86	Sine wave amplitude
R6	1 MHz range frequency	R88	Sine wave distortion #1
R14	Low end dial calibrate	R94	Sine wave distortion #2
R19	Current source driver offset	R100	Sine wave DC level
R25	Positive current balance	R235	AM DC level

Current Source Calibration

1. Set FREQ dial to reading of .002.

2. Connect the DC voltmeter across R18 and adjust R14 for exactly 10 millivolts on the meter.

3. Connect the DC voltmeter across R24 and adjust R19 for exactly 10 millivolts on the meter.

4. Connect the DC voltmeter across R31 and adjust R26 for exactly 10 millivolts on the meter.

5. Connect the DC voltmeter across R29 and adjust R25 for exactly 10 millivolts on the meter.

Frequency Dial Calibration

1. Set the FREQ dial to 1.5.

2. Connect the TTL OUT signal to a frequency counter.

3. Set RANGE switch to 1M and adjust R6 for 1.5 MHz on counter.

4. Set the FREQ dial to 2.0.

5. Set RANGE switch to 100K and adjust R5 for 200 kHz on counter.

6. Set RANGE switch to 10K and adjust R4 for 20 kHz on counter.

7. Set RANGE switch to 1K and adjust R3 for 2 kHz on counter.

8. Set RANGE switch to 100 and adjust R2 for 200 Hz on counter. For more accuracy, set counter for period measurement operation and adjust R2 for 5000 μSEC reading on counter.

DC Level Adjustments

1. Connect DC voltmeter to measure DC voltage at 50Ω output jack.

2. Select triangle wave output at 1 kHz.

3. Adjust the front panel DC OFFSET control for zero volts DC on meter.

4. Set CW/AM switch to AM. Adjust R235 for zero volts DC on meter. Return switch to CW position.

5. Select sine wave signal. Adjust R100 for zero volts DC on meter. Return to triangle wave signal.

6. Display TTL OUT signal on oscilloscope.

7. Set front panel controls for tone burst operation: EXT/INT switch to INT, SWEEP RATE control to highest repetition rate (fully clockwise), BURST GATE control to display only a few cycles tone burst, with output predominantly rest time.

8. Adjust R81 for zero volts DC on meter.

Sine Wave Distortion Adjustment

1. Set FREQ dial to 1.0 and RANGE switch to 1K (1 kHz output).

2. Select sine wave signal.

3. Make sure the output signal is not clipped. Keep the AMPLITUDE control to a mid-range setting and zero out the DC OFFSET control.

4. Connect distortion analyzer to measure the 3020's output signal.

5. Adjust the distortion analyzer for minimum distortion reading.

6. Adjust R88, then R94, for minimum distortion. Repeat until no improvement is noted. Distortion should be below 0.5%.

Amplitude Adjustment

1. Select 1 kHz triangle wave output.

2. Display triangle wave signal on oscilloscope and adjust oscilloscope controls and AMPLITUDE control of 3020 for convenient reference amplitude. Zero out any DC offset with DC OFFSET control.

3. Select square wave signal and adjust R46 for same peak-to-peak amplitude as the triangle wave reference signal.

4. Select sine wave signal and adjust R86 for same peak-to-peak amplitude as triangle wave reference signal. If sine wave distortion adjustments are being performed, complete them before performing this step.

FREQUENCY RESPONSE MEASUREMENTS, LINEAR/LOG DISPLAY
(See page 37 for Linear Only Display Method)

Introduction

The linear/log display method of frequency response measurement gives the user the choice of linear or logarithmic display by merely selecting the LIN (linear) or LOG (logarithmic) position of the LIN/LOG switch on the 3020. This method uses the internally generated sweep of the oscilloscope for horizontal deflection, which is linear with respect to time. Thus, when LIN sweep is selected, the sweep voltage and frequency increase linearly. The time period for each increment of frequency is equal; that is, it requires the same amount of time to sweep from 20 Hz to 2 kHz as from 18 kHz to 20 kHz, or any other 2 kHz increment, when using 20 Hz to 20 kHz sweep. When LOG sweep is selected, the sweep voltage and frequency increase at a logarithmic rate; that is, the time period for each decade of frequency increase (for example, 20 Hz to 200 Hz, 200 Hz to 2000 Hz, and 2000 Hz to 20,000 Hz when using 20 Hz to 20 kHz sweep) is equal.

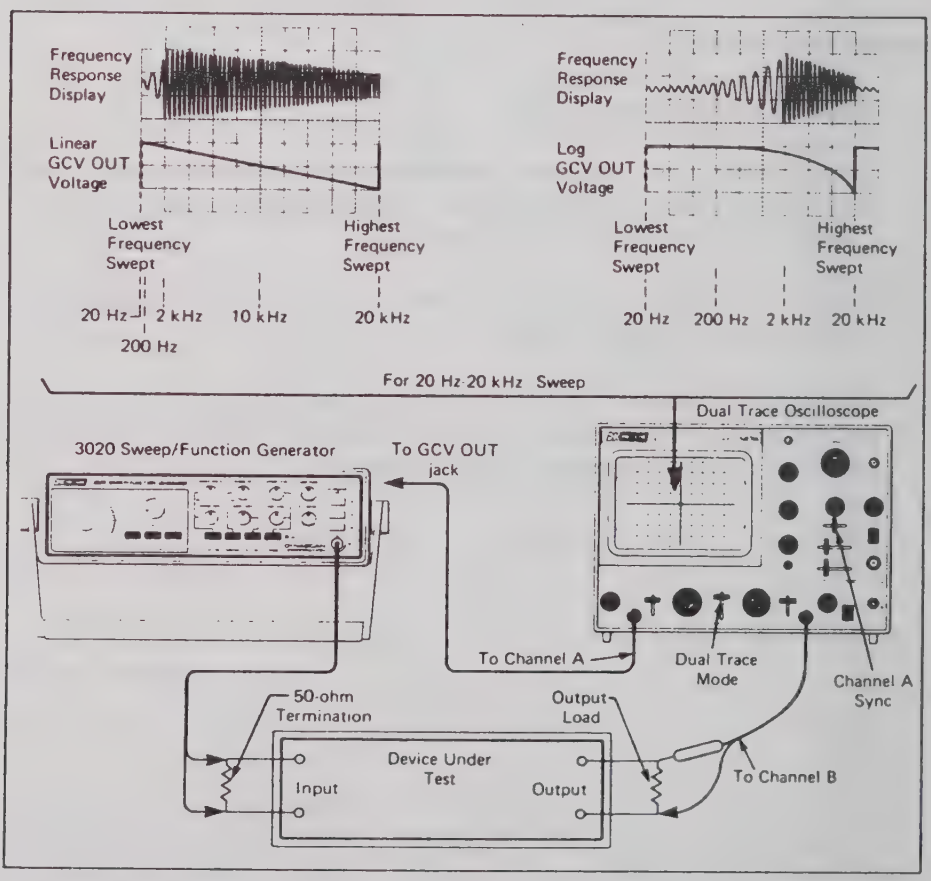


Fig. 27. Frequency response measurement, linear/log display method.

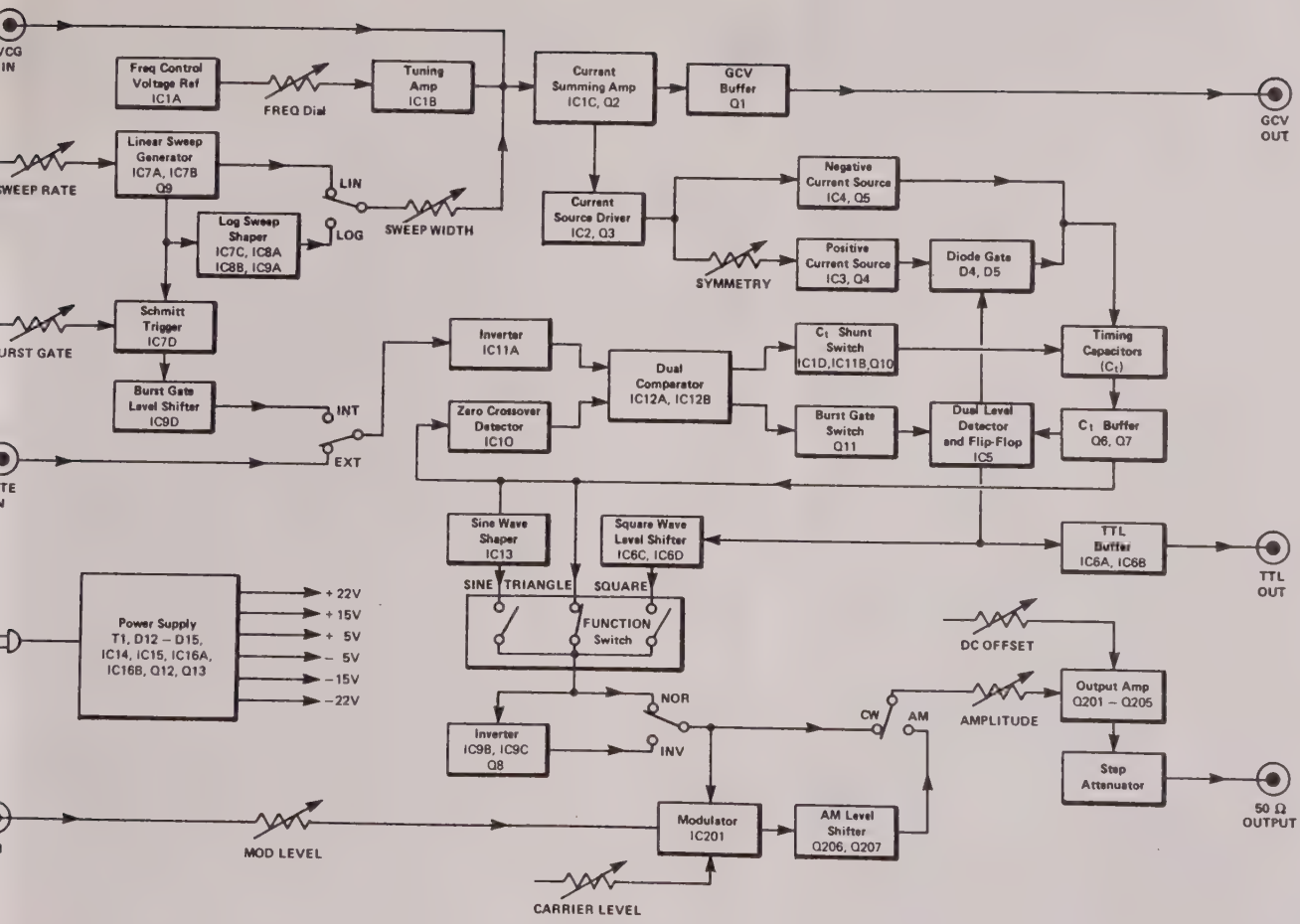


Fig. 28. Block diagram of Model 3020.

Fig. 27 shows that LIN sweep gives more resolution of high frequency response and LOG sweep gives more resolution of low frequency response. Sometimes it is desirable to examine the frequency response characteristics of a device using both LIN and LOG sweep. Notice that this method also provides the conventional left-to-right sweep pattern to which most technicians are accustomed.

Procedure

The following procedures, along with Fig. 27, describes the typical set-up and technique for linear/log frequency response measurements.

1. Select the desired frequency range with the RANGE switch. Choose the range at which the *highest* frequency of the sweep would be selected if dialed in manually.

2. Set the FREQ dial to select the *lowest* frequency to be swept.

3. During initial set-up, turn the SWEEP WIDTH control to OFF, and the SWEEP RATE control to mid-position.

4. Connect a cable from the GCV OUT jack to the vertical input of an oscilloscope (channel A input if a dual-trace oscilloscope is used). Select normal sweep operation; not X-Y operation.

5. Use DC coupling for the oscilloscope vertical input and adjust the oscilloscope controls to display a trace. Use automatic sync on triggered sweep scopes.

6. Use the oscilloscope vertical position control to locate the trace at a convenient reference point toward the top of the screen.

7. Now, set the FREQ dial to the *highest* frequency to be swept. As the frequency is increased, the oscilloscope trace will move down.

8. Use the oscilloscope vertical attenuator/gain controls to position the trace at a convenient reference point toward the bottom of the screen.

9. Repeat steps 2, 6, 7, and 8 so that the low and high frequency trace positions are both at convenient reference points (for example, four vertical divisions apart), and so that any interaction between oscilloscope controls is eliminated.

10. Now return the FREQ dial to the *lowest* frequency to be sweep in preparation for sweep operation.

11. As the SWEEP WIDTH control is turned clockwise, a sweep voltage waveform will be displayed. The amplitude of this waveform increases as the SWEEP WIDTH control is turned further clockwise. Adjust oscilloscope controls to display a few cycles of the waveform. Adjust the SWEEP WIDTH control so that the amplitude of the waveform exactly spans the vertical distance between the low and high frequency reference points from step 9. Do not change the SWEEP WIDTH control setting after this step.

12. Adjust the SWEEP RATE control to the desired repetition rate. For viewing convenience, the highest possible setting is desirable. However, it must be set low enough to obtain a few cycles at the lowest frequencies being swept. Readjust the oscilloscope sweep speed to display one cycle of the sweep voltage waveform. The time period of the sweep may be measured on the oscilloscope if desired. At very low SWEEP RATE settings, the trace may appear as a dot moving across the oscilloscope screen. Watch for the positive-going transition at the end of the waveform to define one cycle.

13. Readjust oscilloscope sweep speed to spread one cycle of the waveform over some convenient number of horizontal division. Each division can later serve as a frequency marker if the corresponding frequency is calculated. For example, a linear display may be spread over 10 horizontal divisions. Since the lowest and highest frequencies are already known, the difference may be divided into 10 equal increments. The example in Fig. 27 shows a 20 Hz to 20 kHz linear sweep display spread over 10 divisions. The difference between the lowest and highest frequency is almost 20 kHz. Therefore, starting from the left of the display at 20 Hz, each division equals a frequency increase of 2 kHz. When log display is used, frequency increases at a logarithmic rate and markers between the lowest and highest frequencies must be scaled logarithmically. The example in Fig. 27 shows a 1000:1 log sweep display spread over nine horizontal divisions. Each three divisions equals a decade of frequency change; that is, after three divisions, the frequency has increased one decade or 10:1 (from 20 Hz to 200 Hz), after six divisions the frequency has increased another decade or 100:1 (to 2 kHz), and after nine divisions the frequency has increased another decade or 1000:1 (to 20 kHz).

14. Connect the 50Ω output of the 3020 to the input of the circuit being tested. Connect a 50-ohm termination across the input terminals (not required if the input impedance is 50 ohms). Connect the output of the circuit being tested into its normal load impedance.

15. If a single-trace oscilloscope is used, disconnect the GCV OUT voltage from the vertical input of the oscilloscope and use it as an external sync signal. Connect the vertical input of the oscilloscope to measure the voltage across the output of the circuit being tested.

    If a dual-trace oscilloscope is used, use the channel A attenuator/gain controls to reduce the amplitude of the sweep voltage waveform to about two vertical divisions and position the channel A trace toward the bottom of the screen as shown in Fig. 27. Sync the oscilloscope to the channel A signal. Connect the channel B input of the oscilloscope to measure the voltage across the output load of the circuit being tested.

16. Adjust the signal amplitude of the 3020 output with the AMPLITUDE control and ATTENUATION buttons. The frequency response display should now be seen on the oscilloscope screen. Adjust the oscilloscope vertical or channel B attenuator/gain controls for the desired amplitude on the display. Be sure to keep the signal level out of the 3020 below the clipping level of the circuit being tested. To prevent clipping, start with a low signal level from the 3020 and increase signal amplitude until the highest peak on the display no longer increases as the AMPLITUDE control is increased, then reduce amplitude slightly below that point.

17. Select LIN or LOG display as desired. When switching from LIN to LOG, or vice versa, you may wish to readjust the oscilloscope sweep speed to spread the display over a different number of horizontal divisions for frequency markers. On a single trace oscilloscope, it will probably be necessary to reconnect and observe the GCV OUT sweep voltage waveform for making this adjustment.

18. The SWEEP RATE may be changed if necessary by repeating steps 12 thru 17. The procedure must be started from the beginning to change the SWEEP WIDTH.

WARRANTY SERVICE INSTRUCTIONS
(For U.S.A. and its Overseas Territories)

1. Refer to the MAINTENANCE section of your **B & K-Precision** instruction manual for adjustments that may be applicable.

2. If the above-mentioned does not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-Precision, Factory Service Department
Maxtec International Corporation
6470 West Cortland Street
Chicago, Illinois 60635
Tel (312) 889-1448

Also use this address for technical inquiries
and replacement parts orders.

LIMITED ONE-YEAR WARRANTY

MAXTEC INTERNATIONAL CORPORATION warrants to the original purchaser that its **B & K-Precision** product, and the component parts thereof, will be free from defects in workmanship and materials for a period of one year from the date of purchase.

MAXTEC will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized **B & K-Precision** service contractor or the factory service department, accompanied by proof of the purchase date in the form of a sales receipt.

To obtain warranty coverage in the U.S.A., this product must be registered by completing and mailing the enclosed warranty registration card to MAXTEC, **B & K-Precision**, 6470 West Cortland Street, Chicago, Illinois 60635 within fifteen (15) days from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

MAXTEC shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your **B & K-Precision** distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to **B & K-Precision** Service Department, 6470 West Cortland Street Chicago, Illinois 60635, properly packaged to avoid damage in shipment.

B & K-Precision Test Instruments warrants products sold only in the U.S.A. and its overseas territories. In other countries, each distributor warrants the B & K-Precision products which it sells.

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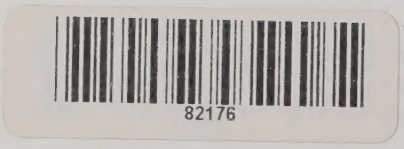

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480-243-9-001H

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